

Capital and Operating Costs for
Industrial Boilers

PEDCo-Environmental, Inc.
Cincinnati, OH

Prepared for

Environmental Protection Agency
Research Triangle Park, NC

Jun 79



TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA/450/5-80-007		2.		3. RECIPIENT'S ACCESSION NO. PB81 105934	
4. TITLE AND SUBTITLE Capital and Operating Costs for Industrial Boilers				5. REPORT DATE June 1979	
7. AUTHOR(S) Larry L. Gibbs, John P. Abraham, N. David Noe, Duane S. Forste, and Harry T. Kimball				6. PERFORMING ORGANIZATION CODE	
9. PERFORMING ORGANIZATION NAME AND ADDRESS PEDCo Environmental, Inc. 11499 Chester Road Cincinnati, Ohio 45246				8. PERFORMING ORGANIZATION REPORT NO.	
12. SPONSORING AGENCY NAME AND ADDRESS EPA, Office of Air Quality Planning and Standards Economic Analysis Branch MD-12 Research Triangle Park, NC 27711				10. PROGRAM ELEMENT NO. B111 - A2A	
				11. CONTRACT/GRANT NO. 68-02-3074 Work Assignment 7	
				13. TYPE OF REPORT AND PERIOD COVERED Final; 4/79 - 6/79	
				14. SPONSORING AGENCY CODE	
15. SUPPLEMENTARY NOTES EPA project officer is John Pratapas, Mail Drop 12 919/541-5420					
16. ABSTRACT The report provides estimates of capital and operating costs for industrial boilers. Costs are related to the type of fuel fired, firing design and rated capacity. Both package and field-erected boilers are evaluated. Fuels considered include coal, residual oil, distillate oil and natural gas. Firing designs for coal include underfeed-stoker, spreader-stoker and pulverized. Rated capacities range from 15(10 ⁶)Btu/hr for oil and gas to 700(10 ⁶)Btu/hr for coal. Costs are developed on a study estimate basis. Individual boiler cost estimates were plotted and cost equations developed for total equipment, installation (direct and indirect) and operating costs (variable and fixed).					
17. KEY WORDS AND DOCUMENT ANALYSIS					
a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS		c. COSATI Field/Group	
Boilers Costs		Industrial Boilers Capital Costs Operating Costs Cost Equations			
18. DISTRIBUTION STATEMENT Release to public		19. SECURITY CLASS (This Report) Unclassified		21. NO. OF PAGES	
		20. SECURITY CLASS (This page) Unclassified		22. PRICE	

PB81-105934

United States
Environmental Protection
Agency

Office of Air Quality
Planning and Standards
Research Triangle Park NC 27711

EPA-450/5-80-007
June 1979

Air



Capital and Operating Costs for Industrial Boilers

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U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA 22161

Capital and Operating Costs for Industrial Boilers

by

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PEDCo Environmental, Inc.
11499 Chester Road
Cincinnati, Ohio 45246

Contract No. 68-02-3074

Task No. 7

EPA Project Officer: John Pratapas

Prepared for

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air, Noise, and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

June 1979

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ACKNOWLEDGEMENT

This report was prepared for the Office of Air Quality, Planning and Standards of the U.S. Environmental Protection Agency. The EPA Project Officer was John M. Pratapas. PEDCo appreciates his direction and assistance.

The PEDCo Project Director was Mr. William F. Kemner. Mr. Larry L. Gibbs was Project Manager. Principal authors were Messrs. Gibbs, John P. Abraham, Duane S. Forste, N. David Noe, and Harry T. Kimball.

1.0 INTRODUCTION

The purpose of this study is to develop general equations to relate the costs of various types of boilers to parameters such as fuel type, fuel analysis, operating hours, and input capacity. The equations are to represent a cross section of fuel types including several ranks of coal, distillate oil, residual oil, and natural gas, and a cross section of boiler types including fire-tube, package water-tube, field-erected water-tube, stoker coal-fired, and pulverized coal-fired.

These equations will be used by the Office of Air Quality, Planning and Standards (OAQPS) as input to a computer model to be used in evaluating the economic impacts of various alternative regulatory scenarios as applied to new industrial boilers.

The specific equations to be developed were for distillate oil-fired fire-tube, residual oil-fired fire-tube, natural gas-fired fire-tube, stoker coal-fired package water-tube, residual oil/natural gas-fired package water-tube, distillate oil/natural gas-fired package water-tube, stoker coal-fired field-erected water-tube, pulverized coal-fired field-erected water-tube, residual oil/natural gas-fired field-erected water-tube, and distillate oil/natural gas-fired field-erected water-tube. To develop these equations, 51 specific boiler/fuel combinations

were costed. In addition, costs for 8 other boiler/fuel combinations developed previously under Contract No. 68-02-2603, Task 19 were used in development of the equations. This report summarizes the equations for the 10 major boiler/fuel combinations and presents detailed costs for the 59 specific boilers used in developing these equations.

In Section 2 are presented the characteristics of the specific boiler types, fuels, and sizes for which costs were prepared. Section 3 presents the detailed costs for 59 boilers and the methodology used to obtain costs. Section 4 presents the equations describing boiler costs and the methodology for obtaining these equations. Appendices A, B, and C present the detailed cost tables for the 59 boilers.

2.0 SPECIFIC BOILERS AND CHARACTERISTICS

The boilers were selected jointly by PEDCo and OAQPS for detailed costing to cover the size range and fuel types of boilers typically found in industrial use. A minimum number of boilers were chosen that would still provide a good basis for development of boiler cost equations. The boilers selected for detailed costing are listed in Table 1.

Operational and design parameters had to be specified for the selected boilers before the costs could be estimated. The following key operating and design parameters are required for each boiler:

- ° Boiler configuration
- ° Design heat input rate
- ° Fuel analysis
- ° Fuel consumption
- ° Excess air usage
- ° Flue gas characteristics
- ° Load factor

The values determined for these operating and design parameters (Tables 2 through 19) are based on published data and practical knowledge of good boiler operating practices. The methodology used to determine these values is described below.

TABLE 1. LIST OF BOILERS COSTED FOR DEVELOPMENT OF COST EQUATIONS

Boiler type	Heat input, 10 ⁶ Btu/h	Steam generating Capacity, 10 ³ lb/h	Fuel
Package water-tube, underfeed stoker	15	12.0	Eastern high-sulfur coal
Package water-tube, underfeed stoker	15	12.0	Eastern low-sulfur coal
Package water-tube, underfeed stoker	15	12.0	Subbituminous coal
Package water-tube, underfeed stoker	30	12.0	Eastern medium-sulfur coal
Package water-tube, underfeed stoker	30	24.0	Eastern high-sulfur coal
Package water-tube, underfeed stoker	30	24.0	Eastern low-sulfur coal
Package water-tube, underfeed stoker	30	24.0	Subbituminous coal
Package water-tube, underfeed stoker	60	48.0	Eastern medium-sulfur coal
Package water-tube, underfeed stoker	60	48.0	Eastern high-sulfur coal
Package water-tube, underfeed stoker	60	48.0	Eastern low-sulfur coal
Package water-tube, underfeed stoker	60	48.0	Subbituminous coal
Field-erected water-tube spreader stoker	75	60.0	Eastern medium-sulfur coal
Field-erected water-tube spreader stoker	75	60.0	Eastern high-sulfur coal
Field-erected water-tube spreader stoker	75	60.0	Eastern low-sulfur coal
Field-erected water-tube spreader stoker	75	60.0	Subbituminous coal
Field-erected water-tube spreader stoker	150	120.0	Eastern medium-sulfur coal
Field-erected water-tube spreader stoker	150	120.0	Eastern high-sulfur coal
Field-erected water-tube spreader stoker	150	120.0	Eastern low-sulfur coal
Field-erected water-tube spreader stoker	150	120.0	Subbituminous coal
Field-erected water-tube spreader stoker	200	160.0	Eastern medium-sulfur coal
Field-erected water-tube spreader stoker	200	160.0	Eastern high-sulfur coal
Field-erected water-tube spreader stoker	200	160.0	Eastern low-sulfur coal
Field-erected water-tube spreader stoker	200	160.0	Subbituminous coal
Field-erected water-tube pulverized	200	160.0	Eastern medium-sulfur coal
Field-erected water-tube pulverized	200	160.0	Eastern high-sulfur coal
Field-erected water-tube pulverized	200	160.0	Eastern low-sulfur coal
Field-erected water-tube pulverized	200	160.0	Subbituminous coal
Field-erected water-tube pulverized	400	320.0	Eastern medium-sulfur coal
Field-erected water-tube pulverized	400	320.0	Eastern high-sulfur coal
Field-erected water-tube pulverized	400	320.0	Eastern low-sulfur coal
Field-erected water-tube pulverized	400	320.0	Subbituminous coal
Field-erected water-tube pulverized	400	320.0	Eastern medium-sulfur coal

(continued)

TABLE 1. (continued)

Boiler type	Heat input, 10 ⁶ Btu/h	Steam generating Capacity, 10 ³ lb/h	Fuel
Field-erected water-tube pulverized	700	560.0	Eastern high-sulfur coal
Field-erected water-tube pulverized	700	560.0	Eastern low-sulfur coal
Field-erected water-tube pulverized	700	560.0	Subbituminous coal
Package fire-tube	5	4.0	Eastern medium-sulfur coal
Package fire-tube	5	4.0	Distillate oil
Package fire-tube	5	4.0	Natural gas
Package fire-tube	15	12.0	Residual oil
Package fire-tube	15	12.0	Distillate oil
Package fire-tube	15	12.0	Natural gas
Package fire-tube	29	23.2	Residual oil
Package fire-tube	29	23.2	Distillate oil
Package fire-tube	29	23.2	Natural gas
Package water-tube	30	24.0	Residual oil
Package water-tube	60	48.0	Residual oil/natural gas
Package water-tube	100	80.0	Residual oil/natural gas
Package water-tube	150	120.0	Residual oil/natural gas
Field-erected water-tube	200	160.0	Residual oil/natural gas
Field-erected water-tube	400	320.0	Residual oil/natural gas
Field-erected water-tube	700	560.0	Residual oil/natural gas
Package water-tube	30	24.0	Distillate oil/natural gas
Package water-tube	60	48.0	Distillate oil/natural gas
Package water-tube	100	80.0	Distillate oil/natural gas
Package water-tube	150	120.0	Distillate oil/natural gas
Field-erected water-tube	200	160.0	Distillate oil/natural gas
Field-erected water-tube	400	320.0	Distillate oil/natural gas
Field-erected water-tube	700	560.0	Distillate oil/natural gas

TABLE 2. DESIGN PARAMETERS FOR COAL-FIRED, PACKAGE,
WATER-TUBE, UNDERFED-STOKER BOILERS

Thermal input, MW (10^6 Btu/h)	4.4 (15)	4.4 (15)	4.4 (15)	4.4 (15)
Fuel	Eastern high-sulfur coal	Eastern low-sulfur coal	Subbituminous coal	Eastern medium-sulfur coal
Fuel rate, kg/s (tons/h)	0.16 (0.64)	0.14 (0.54)	0.20 (0.78)	0.14 (0.57)
Analysis				
% sulfur	3.5	0.9	0.6	2.3
% ash	10.6	6.9	5.4	13.2
Heating value, kJ/kg (Btu/lb)	27,447 (11,800)	32,099 (13,800)	22,330 (9,600)	30,703 (13,200)
Excess air, %	50	50	50	50
Flue gas flow rate, m^3/s (acfm)	3.04 (6450)	2.88 (6100)	2.95 (6250)	2.98 (6325)
Flue gas temperature, °K (°F)	478 (400)	450 (350)	450 (350)	450 (350)
Load factor, %	60	60	60	60
Utility requirements				
Electricity, kW	190	162	213	169
Process water, liters/s (gpm)	0.30 (4.8)	0.30 (4.8)	0.30 (4.8)	0.30 (4.8)
Manpower requirements				
Direct labor, man-yr	5	5	5	5
Supervision, man-yr	2	2	2	2
Maintenance labor, man-yr	2	2	2	2
Bottom ash disposal requirement, kg/h (ton/h)	46.16 (0.05)	25.35 (0.03)	28.66 (0.03)	51.19 (0.06)

TABLE 3. DESIGN PARAMETERS FOR COAL-FIRED, PACKAGE,
WATER-TUBE, UNDERFEED-STOKER BOILERS

Thermal input, MW (10^6 Btu/h)	8.8 (30)	8.8 (30)	8.8 (30)	8.8 (30)
Fuel	Eastern high-sulfur coal	Eastern low-sulfur coal	Subbituminous coal	Eastern medium-sulfur coal
Fuel rate, kg/s (ton/h)	0.32 (1.27)	0.27 (1.09)	0.39 (1.56)	0.28 (1.13)
Analysis				
% sulfur	3.5	0.9	0.6	2.3
% ash	10.6	6.9	5.4	13.2
Heating value, kJ/kg	27,447	32,099	22,330	30,703
(Btu/lb)	(11,800)	(13,800)	(9600)	(13,200)
Excess air, %	50	50	50	50
Flue gas flow rate, m^3/s (acfm)	6.09 (12,900)	5.76 (12,200)	5.90 (12,500)	5.97 (12,650)
Flue gas temperature, °K (°F)	478 (400)	450 (350)	450 (350)	450 (350)
Load factor, %	60	60	60	60
Utility requirements				
Electricity, kW	296	253	364	264
Process water, liters/s (gpm)	0.61 (9.6)	0.61 (9.6)	0.61 (9.6)	0.61 (9.6)
Manpower requirements				
Direct labor, man-yr	6	6	6	6
Supervision, man-yr	2	2	2	2
Maintenance labor, man-yr	2	2	2	2
Bottom ash disposal requirement, kg/h (ton/h)	90.71 (0.10)	54.43 (0.06)	54.43 (0.06)	99.78 (0.11)

TABLE 4. DESIGN PARAMETERS FOR COAL-FIRED, PACKAGE,
WATER-TUBE, UNDERFEED-STOKER BOILERS

Thermal input, MW (10^6 Btu/h)	17.6 (60)	17.6 (60)	17.6 (60)	17.6 (60)	17.6 (60)
Fuel	Eastern high-sulfur coal	Eastern low-sulfur coal	Subbituminous coal	Eastern medium-sulfur coal	
Fuel rate, kg/s (tons/h)	0.64 (2.54)	0.55 (2.18)	0.78 (3.12)	0.57 (2.25)	
Analysis					
% sulfur	3.5	0.9	0.6	2.3	
% ash	10.6	6.9	5.4	13.2	
Heating value, kJ/kg (Btu/lb)	27,447 (11,800)	32,099 (13,800)	22,330 (9,600)	30,703 (13,200)	
Excess air, %	50	50	50	50	
Flue gas flow rate, m^3/s (acfm)	12.18 (25,800)	11.52 (24,400)	11.80 (25,000)	11.94 (25,300)	
Flue gas temperature, °K (°F)	478 (400)	450 (350)	450 (350)	450 (350)	
Load factor, %	60	60	60	60	
Utility requirements					
Electricity, kW	392	335	482	350	
Process water, liters/s (gpm)	1.21 (19.2)	1.21 (19.2)	1.21 (19.2)	1.21 (19.2)	
Manpower requirements					
Direct labor, man-yr	7	7	7	7	
Supervision, man-yr	4	4	4	4	
Maintenance labor, man-yr	4	4	4	4	
Bottom ash disposal requirement, kg/h (ton/h)	181.42 (0.20)	99.78 (0.11)	117.92 (0.13)	199.56 (0.22)	

TABLE 5. DESIGN PARAMETERS FOR COAL-FIRED, FIELD-ERECTED,
WATER-TUBE, SPREADER-STOKER BOILERS

Thermal input, MW (10^6 Btu/h)	22.0 (75)	22.0 (75)	22.0 (75)	22.0 (75)
Fuel	Eastern high-sulfur coal	Eastern low-sulfur coal	Subbituminous coal	Eastern medium-sulfur coal
Fuel rate, kg/s (ton/h)	0.80 (3.18)	0.69 (2.72)	0.99 (3.91)	0.72 (2.82)
Analysis				
% sulfur	3.5	0.9	0.6	2.3
% ash	10.6	6.9	5.4	13.2
Heating value, kJ/kg (Btu/lb)	27,447 (11,800)	32,099 (13,800)	22,330 (9600)	30,703 (13,200)
Excess air, %	50	50	50	50
Flue gas flow rate, m^3/s (acfm)	15.24 (32,300)	14.21 (30,100)	14.82 (31,400)	14.73 (31,200)
Flue gas temperature, °K (°F)	478 (400)	450 (350)	450 (350)	450 (350)
Load factor, %	60	60	60	60
Utility requirements				
Electricity, kW	425	363	523	379
Process water, liters/s (gpm)	1.52 (24.0)	1.52 (24.0)	1.52 (24.0)	1.52 (24.0)
Manpower requirements				
Direct labor, man-yr	8	8	8	8
Supervision, man-yr	4	4	4	4
Maintenance labor, man-yr	4	4	4	4
Bottom ash disposal requirement, kg/h (ton/h)	107.03 (0.12)	59.59 (0.07)	67.04 (0.07)	118.19 (0.13)

TABLE 6. DESIGN PARAMETERS FOR COAL-FIRED, FIELD-ERECTED,
WATER-TUBE, SPREADER-STOKER BOILERS

Thermal input, MW (10^6 Btu/h)	44.0 (150)	44.0 (150)	44.0 (150)	44.0 (150)
Fuel	Eastern high-sulfur coal	Eastern low-sulfur coal	Subbituminous coal	Eastern medium-sulfur coal
Fuel rate, kg/s (ton/h)	1.60 (6.36)	1.38 (5.44)	1.98 (7.82)	1.43 (5.63)
Analysis				
% sulfur	3.5	0.9	0.6	2.3
% ash	10.6	6.9	5.4	13.2
Heating value, kJ/kg (Btu/lb)	27,447 (11,800)	32,099 (13,800)	22,330 (9600)	30,703 (13,200)
Excess air, %	50	50	50	50
Flue gas flow rate, m^3/s (acfm)	30.58 (64,800)	28.69 (60,800)	29.64 (62,800)	29.72 (63,000)
Flue gas temperature, °K (°F)	478 (400)	450 (350)	450 (350)	450 (350)
Load factor, %	60	60	60	60
Utility requirements				
Electricity, kW	628	537	773	561
Process water, liters/s (gpm)	3.03 (48.0)	3.03 (48.0)	3.03 (48.0)	3.03 (48.0)
Manpower requirements				
Direct labor, man-yr	12	12	12	12
Supervision, man-yr	4	4	4	4
Maintenance labor, man-yr	4	4	4	4
Bottom ash disposal requirement, kg/h (ton/h)	217.70 (0.24)	117.92 (0.13)	136.07 (0.15)	235.85 (0.26)

TABLE 7. DESIGN PARAMETERS FOR COAL-FIRED, FIELD-ERECTED,
WATER-TUBE, SPREADER-STOKER BOILERS

Thermal input, MW (10^6 Btu/h)	58.6 (200)	58.6 (200)	58.6 (200)	58.6 (200)
Fuel	Eastern high-sulfur coal	Eastern low-sulfur coal	Subbituminous coal	Eastern medium-sulfur coal
Fuel rate, kg/s (tons/h)	2.13 (8.48)	1.84 (7.25)	2.64 (10.43)	1.91 (7.51)
Analysis				
% sulfur	3.5	0.9	0.6	2.3
% ash	10.6	6.9	5.4	13.2
Heating value, kJ/kg (Btu/lb)	27,447 (11,800)	32,099 (13,800)	22,330 (9,600)	30,703 (13,200)
Excess air, %	50	50	50	50
Flue gas flow rate, m^3/s (acfm)	40.77 (86,400)	38.27 (81,100)	39.52 (83,700)	39.65 (84,000)
Flue gas temperature, °K (°F)	478 (400)	450 (350)	450 (350)	450 (350)
Load factor, %	60	60	60	60
Utility requirements				
Electricity, kW	813	695	1001	726
Process water, liters/s (gpm)	4.04 (64.0)	4.04 (64.0)	4.04 (64.0)	4.04 (64.0)
Manpower requirements				
Direct labor, man-yr	16	16	16	16
Supervision, man-yr	4	4	4	4
Maintenance labor, man-yr	6	6	6	6
Bottom ash disposal requirement, kg/h (ton/h)	281.20 (0.31)	163.28 (0.18)	181.42 (0.20)	317.49 (0.35)

TABLE 8. DESIGN PARAMETERS FOR FIELD-ERECTED, WATER-TUBE,
PULVERIZED-COAL-FIRED BOILERS

Thermal input, MW (10^6 Btu/h)	58.6 (200)	58.6 (200)	58.6 (200)	58.6 (200)
Fuel	Eastern high-sulfur coal	Eastern low-sulfur coal	Subbituminous coal	Eastern medium-sulfur coal
Fuel rate, kg/s (ton/h)	2.13 (0.48)	1.84 (7.25)	2.64 (10.43)	1.91 (7.51)
Analysis				
% sulfur	3.5	0.9	0.6	2.3
% ash	10.6	6.9	5.4	13.2
Heating value, kJ/kg (Btu/lb)	27,447 (11,800)	32,099 (13,800)	22,330 (9,600)	30,703 (13,200)
Excess air, %	30	30	30	30
Flue gas flow rate, m^3/s (acfm)	35.30 (74,800)	33.32 (70,600)	34.55 (73,200)	34.62 (73,400)
Flue gas temperature, $^{\circ}K$ ($^{\circ}F$)	478 (400)	450 (350)	450 (350)	450 (350)
Load factor, %	60	60	60	60
Utility requirements				
Electricity, kW	2052	1754	2526	1831
Process water, liters/s (gpm)	4.04 (64.0)	4.04 (64.0)	4.04 (64.0)	4.04 (64.0)
Manpower requirements				
Direct labor, man-yr	16	16	16	16
Supervision, man-yr	4	4	4	4
Maintenance labor, man-yr	6	6	6	6
Bottom ash disposal requirement, kg/h (ton/h)	163.28 (0.18)	90.71 (0.10)	99.78 (0.11)	181.42 (0.20)

TABLE 9. DESIGN PARAMETERS FOR FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILERS

Thermal input, MW (10^6 Btu/h)	117.2 (400)	117.2 (400)	117.2 (400)	117.2 (400)
Fuel	Eastern high-sulfur coal	Eastern low-sulfur coal	Subbituminous coal	Eastern medium-sulfur coal
Fuel rate, kg/s (ton/h)	4.27 (16.95)	3.65 (14.49)	5.25 (20.83)	3.82 (15.14)
Analysis				
% sulfur	3.5	0.9	0.6	2.3
% ash	10.6	6.9	5.4	13.2
Heating value, kJ/kg (Btu/lb)	27,447 (11,800)	32,099 (13,800)	22,330 (9600)	30,703 (13,200)
Excess air, %	30	30	30	30
Flue gas flow rate, m^3/s (acfm)	70.63 (149,600)	66.80 (141,500)	68.89 (146,000)	71.35 (151,200)
Flue gas temperature, °K (°F)	478 (400)	450 (350)	450 (350)	478 (400)
Load factor, %	60	60	60	60
Utility requirements				
Electricity, kW	4142	3540	5097	3695
Process water, liters/s (gpm)	8.08 (128.0)	8.08 (128.0)	8.08 (128.0)	8.08 (128.0)
Manpower requirements				
Direct labor, man-yr	28	28	28	28
Supervision, man-yr	6	6	6	6
Maintenance labor, man-yr	12	12	12	12
Bottom ash disposal requirement, kg/h (ton/h)	326.56 (0.36)	181.42 (0.20)	199.56 (0.22)	362.84 (0.40)

TABLE 10. DESIGN PARAMETERS FOR FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILERS

Thermal input, MW (10^6 Btu/h)	205.1 (700)	205.1 (700)	205.1 (700)	205.1 (700)
Fuel	Eastern high-sulfur coal	Eastern low-sulfur coal	Subbituminous coal	Eastern medium-sulfur coal
Fuel rate, kg/s (tons/h)	7.47 (29.66)	6.39 (25.36)	9.19 (36.46)	6.68 (26.52)
Analysis				
t sulfur	3.5	0.9	0.6	2.3
t ash	10.6	6.9	5.4	13.2
Heating value, kJ/kg (Btu/lb)	27,447 (11,800)	32,099 (13,800)	22,330 (9,600)	30,703 (13,200)
Excess air, t	30	30	30	30
Flue gas flow rate, m^3/s (acfm)	123.55 (261,800)	116.62 (247,100)	120.93 (256,200)	121.17 (256,900)
Flue gas temperature, °K (°F)	478 (400)	450 (350)	450 (350)	450 (350)
Load factor, t	60	60	60	60
Utility requirements				
Electricity, kW	7249	6195	8920	6466
Process water, liters/s (gpm)	14.14 (224.0)	14.14 (224.0)	14.14 (224.0)	14.14 (224.0)
Manpower requirements				
Direct labor, man-yr	38	38	38	38
Supervision, man-yr	6	6	6	6
Maintenance labor, man-yr	16	16	16	16
Bottom ash disposal requirement, kg/h (ton/h)	570.43 (0.63)	317.49 (0.35)	357.22 (0.39)	635.14 (0.70)

TABLE 11. DESIGN PARAMETERS FOR PACKAGE, FIRE-TUBE
BOILERS FIRING RESIDUAL OIL

Thermal input, MW (10^6 Btu/h)	1.5 (5)	4.4 (15)	8.5 (29)
Fuel	Residual oil	Residual oil	Residual oil
Fuel rate, m^3/h (gal/h)	0.13 (33.4)	0.38 (100.1)	0.73 (193.6)
Analysis			
% sulfur	3.0	3.0	3.0
% ash	0.1	0.1	0.1
Heating value, MJ/m^3 (Btu/gal)	41,714 (149,800)	41,714 (149,800)	41,714 (149,800)
Excess air, %	15	15	15
Flue gas flow rate, m^3/s (acfm)	0.75 (1,600)	2.21 (4,700)	4.28 (9,100)
Flue gas temperature, °K (°F)	478 (400)	478 (400)	478 (400)
Load factor, %	45	45	45
Utility requirements			
Electricity, kW	59	114	236
Process water, liter/s (gpm)	0.10 (1.6)	0.30 (4.8)	0.60 (9.5)
Manpower requirements			
Direct labor, man-yr	4	4	4
Supervision, man-yr		2	2
Maintenance labor, man-yr	0.5	1	1
Bottom ash disposal requirement kg/h (tons/h)	Negligible	Negligible	Negligible

TABLE 12. DESIGN PARAMETERS FOR PACKAGE, FIRE-TUBE
BOILERS FIRING DISTILLATE OIL

Thermal input, MW (10^6 Btu/h)	1.5 (5)	4.4 (15)	8.5 (29)
Fuel	Distillate oil	Distillate oil	Distillate oil
Fuel rate, m^3/h (gal/h)	0.14 (36.0)	0.41 (107.9)	0.79 (208.6)
Analysis			
% sulfur	0.5	0.5	0.5
% ash	Trace	Trace	Trace
Heating value, MJ/ m^3 (Btu/gal)	38,712 (139,000)	38,712 (139,000)	38,712 (139,000)
Excess air, %	15	15	15
Flue gas flow rate, m^3/s (acfm)	0.81 (1700)	2.36 (5000)	4.45 (9700)
Flue gas temperature, °K (°F)	450 (350)	450 (350)	450 (350)
Load factor, %	45	45	45
Utility requirements			
Electricity, kW	59	114	236
Process water, liter/s (gpm)	0.10 (1.6)	0.30 (4.8)	0.60 (9.5)
Manpower requirements			
Direct labor, man-yr	4	4	4
Supervision, man-yr		2	2
Maintenance labor, man-yr	.5	1	1
Bottom ash disposal requirement, kg/h (ton/h)	Negligible	Negligible	Negligible

TABLE 13. DESIGN PARAMETERS FOR PACKAGE, FIRE-TUBE
BOILERS FIRING NATURAL GAS

Thermal input, MW (10^6 Btu/h)	1.5 (5)	4.4 (15)	8.5 (29)
Fuel	Natural gas	Natural gas	Natural gas
Fuel rate, m^3/s (ft^3/h)	0.04 (5000)	0.12 (15,000)	0.23 (29,000)
Analysis			
% sulfur	Trace	Trace	Trace
% ash	Trace	Trace	Trace
Heating value, kJ/m^3 (Btu/ ft^3)	37,218 (1000)	37,218 (1000)	37,218 (1000)
Excess air, %	15	15	15
Flue gas flow rate, m^3/s (acfm)	0.81 (1700)	2.45 (5200)	4.74 (10,100)
Flue gas temperature, °K (°F)	450 (350)	450 (350)	450 (350)
Load factor, %	45	45	45
Utility requirements			
Electricity, kW	59	114	236
Process water, liter/s (gpm)	0.10 (1.6)	0.30 (4.8)	0.60 (9.5)
Manpower requirements			
Direct labor, man-yr	4	4	4
Supervision, man-yr	.5	2	2
Maintenance labor, man-yr		1	1
Bottom ash disposal requirement, kg/h (ton/h)	Negligible	Negligible	Negligible

TABLE 14. DESIGN PARAMETERS FOR PACKAGE, WATER-TUBE
BOILERS FIRING RESIDUAL OIL

Thermal input, MW (10^6 Btu/h)	8.8 (30)	17.6 (60)	29.3 (100)	44.0 (150)
Fuel	Residual oil	Residual oil	Residual oil	Residual oil
Fuel rate, m^3/h (gal/h)	0.76 (200.3)	1.52 (400.5)	2.53 (667.6)	3.79 (1001.3)
Analysis				
% sulfur	3.0	3.0	3.0	3.0
% ash	0.1	0.1	0.1	0.1
Heating value, MJ/ m^3 (Btu/gal)	41,714 (149,800)	41,714 (149,800)	41,714 (149,800)	41,714 (149,800)
Excess air, %	15	15	15	15
Flue gas flow rate, m^3/s (acfm)	4.62 (9800)	9.25 (19,600)	15.43 (32,700)	23.12 (49,000)
Flue gas temperature, $^{\circ}K$ ($^{\circ}F$)	478 (400)	478 (400)	478 (400)	478 (400)
Load factor, %	55	55	55	55
Utility requirements				
Electricity, kw	236	265	316	379
Process water, liter/s (gpm)	0.61 (9.6)	1.21 (19.2)	2.02 (32.0)	3.03 (48.0)
Manpower requirements				
Direct labor, man-yr	4	4	6	8
Supervision, man-yr	2	2	2	2
Maintenance labor, man-yr	1	2	2	2
Bottom ash disposal requirement, kg/h (ton/h)	Negligible	Negligible	Negligible	Negligible

TABLE 15. DESIGN PARAMETERS FOR PACKAGE, WATER-TUBE
BOILERS FIRING DISTILLATE OIL

Thermal input, MW (10^6 Btu/h)	8.8 (30)	17.6 (60)	29.3 (100)	44.0 (150)
Fuel	Distillate oil	Distillate oil	Distillate oil	Distillate oil
Fuel rate, m^3/h (gal/h)	0.82 (215.8)	1.63 (431.7)	2.72 (719.4)	4.09 (1080.0)
Analysis				
% sulfur	0.5	0.5	0.5	0.5
% ash	Trace	Trace	Trace	Trace
Heating value, MJ/ m^3 (Btu/gal)	38,712 (139,000)	38,712 (139,000)	38,712 (139,000)	38,712 (139,000)
Excess air, %	15	15	15	15
Flue gas flow rate, m^3/s (acfm)	4.36 (9,240)	8.73 (18,500)	14.53 (30,800)	21.78 (46,200)
Flue gas temperature, $^{\circ}K$ ($^{\circ}F$)	450 (350)	450 (350)	450 (350)	450 (350)
Load factor, %	55	55	55	55
Utility requirements				
Electricity, kW	236	265	316	379
Process water, liters/s (gpm)	0.61 (9.6)	1.21 (19.2)	2.02 (32.0)	3.03 (48.0)
Manpower requirements				
Direct labor, man-yr	4	4	6	8
Supervision, man-yr	2	2	2	2
Maintenance labor, man-yr	1	2	2	2
Bottom ash disposal requirement, kg/h (ton/h)	Negligible	Negligible	Negligible	Negligible

TABLE 16. DESIGN PARAMETERS FOR PACKAGE, WATER-TUBE
BOILERS FIRING NATURAL GAS

Thermal input, MW (10^6 Btu/h)	8.8 (30)	17.6 (60)	29.3 (100)	44.0 (150)
Fuel	Natural gas	Natural gas	Natural gas	Natural gas
Fuel rate, m^3/s (ft^3/h)	0.24 (30,000)	0.47 (60,000)	0.79 (100,000)	1.18 (150,000)
Analysis				
% sulfur	Trace	Trace	Trace	Trace
% ash	Trace	Trace	Trace	Trace
Heating value, kJ/m^3 (Btu/ ft^3)	37,218 (1000)	37,218 (1000)	37,218 (1000)	37,218 (1000)
Excess air, %	15	15	15	15
Flue gas flow rate, m^3/s (acfm)	4.43 (9,380)	8.87 (18,800)	14.77 (31,300)	22.15 (46,900)
Flue gas temperature, $^{\circ}K$ ($^{\circ}F$)	450 (350)	450 (350)	450 (350)	450 (350)
Load factor, %	55	55	55	55
Utility requirements				
Electricity, kW	236	265	316	379
Process water, liters/s (gpm)	0.61 (9.6)	1.21 (19.2)	2.02 (32.0)	3.03 (48.0)
Manpower requirements				
Direct labor, man-yr	4	4	6	8
Supervision, man-yr	2	2	2	2
Maintenance labor, man-yr	1	2	2	2
Bottom ash disposal requirement, kg/h (ton/h)	Negligible	Negligible	Negligible	Negligible

TABLE 17. DESIGN PARAMETERS FOR FIELD-ERECTED, WATER-TUBE
BOILERS FIRING RESIDUAL OIL

Thermal input, MW (10^6 Btu/h)	58.6 (200)	117.2 (400)	205.1 (700)
Fuel	Residual oil	Residual oil	Residual oil
Fuel rate, m^3/h (gal/h)	5.05 (1335.1)	10.11 (2670.2)	17.69 (4672.9)
Analysis			
% sulfur	3.0	3.0	3.0
% ash	0.1	0.1	0.1
Heating value, MJ/ m^3 (Btu/gal)	41,714 (149,800)	41,714 (149,800)	41,714 (149,800)
Excess air, %	15	15	15
Flue gas flow rate, m^3/s (acfm)	30.87 (65,400)	61.73 (130,800)	108.03 (228,900)
Flue gas temperature, °K (°F)	478 (400)	478 (400)	478 (400)
Load factor, %	55	55	55
Utility requirements			
Electricity, kW	569	885	1453
Process water, liters/s (gpm)	4.04 (64.0)	8.08 (128.0)	14.14 (224.0)
Manpower requirements			
Direct labor, man-yr	10	18	23
Supervision, man-yr	3	4	4
Maintenance labor, man-yr	3	4	7
Bottom ash disposal requirement, kg/h (ton/h)	Negligible	Negligible	Negligible

TABLE 18. DESIGN PARAMETERS FOR FIELD-ERECTED, WATER-TUBE
BOILERS FIRING DISTILLATE OIL

Thermal input, MW (10^6 Btu/h)	58.6 (200)	117.2 (400)	205.1 (700)
Fuel	Distillate oil	Distillate oil	Distillate oil
Fuel rate, m^3/h (gal/h)	5.45 (1438.8)	10.89 (2877.7)	19.06 (5036.0)
Analysis			
% sulfur	0.5	0.5	0.5
% ash	Trace	Trace	Trace
Heating value, MJ/ m^3 (Btu/gal)	38,712 (139,000)	38,712 (139,000)	38,712 (139,000)
Excess air, %	15	15	15
Flue gas flow rate, m^3/s (acfm)	29.07 (61,600)	58.14 (123,200)	101.76 (215,600)
Flue gas temperature, °K (°F)	450 (350)	450 (350)	450 (350)
Load factor, %	55	55	55
Utility requirements			
Electricity, kW	569	885	1453
Process water, liters/s (gpm)	4.04 (64.0)	8.08 (128.0)	14.14 (224.0)
Manpower requirements			
Direct labor, man-yr	10	18	23
Supervision, man-yr	3	4	4
Maintenance labor, man-yr	3	4	7
Bottom ash disposal requirement, kg/h (ton/h)	Negligible	Negligible	Negligible

TABLE 19. DESIGN PARAMETERS FOR FIELD-ERECTED, WATER-TUBE BOILERS FIRING NATURAL GAS

Thermal input, MW (10^6 Btu/h)	58.6 (200)	117.2 (400)	205.1 (700)
Fuel	Natural gas	Natural gas	Natural gas
Fuel rate, m ³ /s (ft ³ /h)	15.7 (200,000)	3.15 (400,000)	5.51 (700,000)
Analysis			
% sulfur	Trace	Trace	Trace
% ash	Trace	Trace	Trace
Heating value, kJ/m ³ (Btu/ft ³)	37,218 (1000)	37,218 (1000)	37,218 (1000)
Excess air, %	15	15	15
Flue gas flow rate, m ³ /s (acfm)	29.50 (62,500)	59.04 (125,100)	103.31 (218,900)
Flue gas temperature, °K (°F)	450 (350)	450 (350)	450 (350)
Load factor, %	55	55	55
Utility requirements			
Electricity, kW	569	885	1453
Process water, liters/s (gpm)	4.04 (64.0)	8.08 (128.0)	14.14 (224.0)
Manpower requirements			
Direct labor, man-yr	10	18	23
Supervision, man-yr	3	4	4
Maintenance labor, man-yr	3	4	7
Bottom ash disposal requirement, kg/h (ton/h)	Negligible	Negligible	Negligible

BOILER CONFIGURATION

Boiler configuration was specified as an initial step in the selection of representative boilers.

DESIGN HEAT INPUT RATE

This rate is based on the available capacities of the boilers within the selected configurations. The selection of the capacity range reflects the most common capacities within a particular boiler configuration.

FUEL ANALYSIS

Fuel type for each boiler was chosen as part of the initial selection process. The fuel analyses presented in Table 20 for natural gas, distillate oil, and residual oil were determined from data about "average" fuels presented by Babcock & Wilcox (1972). The Babcock & Wilcox analysis of Birmingham natural gas was selected as average. The values selected for distillate oil represent No. 2 fuel oil; they were selected from the middle of the ranges presented, except for sulfur content, which was selected from the upper part of the range for evaluation of a distillate oil with a relatively high sulfur content. The analysis for the residual oil was selected from the ranges of values given for No. 6 fuel oil; again, all values were taken from the middle of the ranges except the sulfur value, which comes from the upper part of the range so that a high-sulfur residual oil can be evaluated.

TABLE 20. ULTIMATE ANALYSES OF FUELS SELECTED FOR THE BOILERS^a

Fuel	Composition, % by weight						Heating value, kJ/kg (Btu/lb)
	Water	Carbon	Hydrogen	Nitrogen	Oxygen	Sulfur	Ash
Natural gas	0.02	69.26	22.67	8.05	Trace	Trace	0
Distillate oil	0.05	87.17	12.28	Trace	Trace	0.50	Trace
Residual oil	0.08	86.62	10.20	Trace	Trace	3.00	0.10
Eastern high-sulfur, high-ash coal	8.79	64.80	4.43	1.30	6.56	3.54	10.58
Eastern medium-sulfur, high-ash coal	0.80	74.80	4.56	1.19	3.17	2.28	13.20
Eastern low-sulfur, low-ash coal	2.54	78.64	4.70	1.48	4.88	0.90	6.86
Western low-sulfur, low-ash coal	20.80	57.60	3.20	1.20	11.20	0.60	5.40
							22,330 (9,600)

^a All analyses are based on engineering judgments by PEDCO about information from Babcock & Wilcox (1972), except for the analysis of eastern medium-sulfur, high-ash coal, which Versar, Inc., provided in a memo of March 22, 1979, to J. Kilgroe, IERL, Research Triangle Park, North Carolina.

Four coal analyses were used to represent the major coal-producing areas and classes of coals available in the United States. Data from Babcock & Wilcox (1972) served as the basis for the analyses of eastern high-sulfur, high-ash, bituminous coal; eastern low-sulfur, low-ash, low-moisture, bituminous coal; and western low-sulfur, low-ash, high-moisture, subbituminous coal. Versar, Inc. provided the analysis of eastern medium-sulfur, high-ash, low-moisture bituminous coal.

FUEL CONSUMPTION

Given the heat input rate specified for each selected boiler in Table 1, fuel consumption was calculated by dividing the heat input rate by the heating value of the fuel used. For example, if a package, water-tube, underfeed stoker with a heat input rate of 8.8 MW thermal (30×10^6 Btu/h) fires eastern coal at 27,447 kJ/kg, the amount of fuel required is equal to $8800 \text{ kJ/s} \div 27,447 \text{ kJ/kg}$, or 0.32 kg/s.

Because input capacities are specified, it is not necessary to consider the efficiencies of boiler heat transfer or fuel burning.

EXCESS AIR USAGE

The amount of excess air selected for each boiler type is based on practical knowledge of good boiler operating practices. Table 21 presents ranges (percentages by weight) of excess air common to different boiler types. A value for each boiler was

TABLE 21. TYPICAL AMOUNTS OF EXCESS AIR SUPPLIED
TO FUEL-BURNING EQUIPMENT^a

Fuel	Type of burners	Excess air, % by weight
Pulverized coal	Partially water-cooled for dry-ash-removal	15-40
Coal	Spreader stoker	30-60
	Chain-grate and traveling-grate stokers	15-50
	Underfeed stoker	20-50
Fuel oil	Multifuel and flat-flame	10-20
Natural gas	Multifuel	7-15

^a Babcock & Wilcox, 1963.

selected out of this range, based upon previous experience and data on boiler operating characteristics.

A mass balance was then performed to obtain the amount of excess air. The combustion air was assumed to have a temperature of 27°C (80°F), a relative humidity of 60 percent, and a pressure of 101 kPa (14.7 psi). The amount of air required for complete combustion of the fuel was calculated on a molal basis from the ultimate analysis of the fuel and the emission rates of the various flue gas constituents.

An example of the procedure is shown below using the package, water-tube, underfeed-stoker boiler with a heat input of 8.8 MW thermal (30×10^6 Btu/h).

The molal configuration for each of the gaseous constituents of the flue gas (determined by emission factors) is calculated by dividing the mass rate by the molecular weight of the constituent. The results for the example boiler are shown below:

<u>Constituent</u>	<u>moles/h</u>
Carbon monoxide (CO)	0.09
Hydrocarbons (as CH ₄)	0.07
Sulfur dioxide (SO ₂)	2.80
Nitrogen oxides (as NO ₂)	0.23

The molal rate of each component is then calculated using the fuel mass rate per hour and the ultimate analysis of the fuel. The results for the example boiler are tabulated below:

<u>Fuel constituent</u>	<u>Mass rate, kg/h (lb/h)</u>	<u>Molal rate</u>
Carbon (C)	12.44 (1646)	137.1
Hydrogen (H ₂)	0.85 (113)	56.1
Sulfur (S)	0.68 (90)	2.8
Oxygen (O ₂)	1.26 (167)	5.2
Nitrogen (N ₂)	0.25 (33)	1.2
Water (H ₂ O)	1.69 (223)	12.4

The remaining flue gas constituents (CO₂, H₂O, N₂) are calculated by molal balance by subtracting the calculated moles of emissions (U.S. EPA, 1975) from the moles of equivalent components in the fuel. For example, the CO and CH₄ represent part of the carbon from the fuel. Assuming the remaining carbon is oxidized to CO₂, the molal quantity of CO₂ is 137.17 moles of carbon minus 0.09 moles of CO minus 0.07 moles of CH₄ or 137.01 moles of CO₂. The results of similar analyses for the other flue gas constituents of the example boiler are as follows:

<u>Constituent</u>	<u>Molal quantity</u>
CO ₂	137.0
H ₂ O	68.5
N ₂	1.1

To calculate the stoichiometric oxygen required, each flue gas constituent is examined in terms of equivalent oxygen content. The following is a presentation of data for the example boiler.

<u>Flue gas constituent</u>	<u>Moles per hour</u>	<u>Moles of O₂ per mole constituent</u>	<u>Moles of O₂ per hour</u>
CO ₂	137.0	1.0	137.0
CO	0.09	0.5	0.4
CH ₄	0.07	0.0	0.0
SO ₂	2.80	1.0	2.8
H ₂ O	68.5	0.5	34.2
NO _x (as NO ₂)	0.23	1	0.23
N ₂	1.1	0.0	<u>0.0</u>
Total			174.27

Of the 174.3 moles of O₂ required, the O₂ in the coal supplies 5.2 moles and the H₂O in the coal supplies 6.2 moles. Therefore the theoretical requirement from the combustion air is 162.9 moles of O₂. The excess air for this boiler is 50 percent of stoichiometric. Therefore the total oxygen required is 1.5 times the theoretical requirement, or 244.4 moles. It was assumed that the combustion air is 21 percent oxygen and 79 percent nitrogen. Therefore the N₂ required is 919 moles. The weight of dry air supplied is then 15,256 kg/h (33,564 lb/h). At the previously assumed combustion air conditions, 6.0212 mole of water is contained in the wet air per mole of dry air (24 moles of H₂O total). The total wet combustion air supplied is then 15,453 kg/h (33,996 lb/h).

FLUE GAS CHARACTERISTICS

The volume of the exit flue gas is dependent upon its composition, the amount of excess air, and the exit temperature. The

total moles of the various flue gas constituents was determined for each boiler in the excess air calculations. At standard conditions, the volume of a mole of gas is 10.2 m^3 (359 ft^3), assuming ideal behavior. Therefore the volume of the flue gas at standard conditions can be calculated.

The actual volume of the flue gas must be calculated at the flue gas temperature. Assumed temperatures of the exit flue gas from each boiler were based on typical temperatures from previous boiler studies. The calculated volumes of flue gas were then adjusted from standard conditions to the actual temperature. It was assumed that the flue gas pressure is constant at 101 kPa (14.7 psi).

For example, for a package, water tube, underfeed-stoker boiler with a heat input of 8.8 MW thermal ($30 \times 10^6 \text{ Btu/h}$), total dry flue gas was calculated to be 1135.9 moles. On a wet basis, flue gas was calculated to be 1228.4 moles. At the assumed exhaust temperature of 478°K (400°F) the flue gas volume is:

$$\begin{aligned}
 &1228.4 \text{ moles/h} \times 10.2 \text{ m}^3/\text{mole} \times \frac{478^\circ\text{K}}{273^\circ\text{K}} = \\
 &21,938 \text{ m}^3/\text{h} \text{ (775,204 ft}^3/\text{h)} \\
 &21,938 \text{ m}^3/\text{h} \div 3600 \text{ s/h} = 6.09 \text{ m}^3/\text{s} \text{ (12,900 ft}^3/\text{min)}
 \end{aligned}$$

LOAD FACTOR

Assumed load factors for the boilers were based on ranges of load factors for industrial boilers. Battelle (Locklin, et al., 1974) estimated load factors in industrial/ commercial boilers to range from 30 to 80 percent. Selection of values from the range

for each representative boiler was based on previous boiler studies and data on typical load factors. The load factors are believed to be representative of new industrial boilers supplying process steam.

UTILITY REQUIREMENTS

A boiler facility requires electricity to operate a variety of equipment. The equipment items include fans, controls, pulverizers or stokers, feeders, crushers, conveyors, pumps, compressors, lights, heating equipment, air conditioning, and instrumentation. For each boiler facility an estimate was made of the electrical requirements for these equipment items based on boiler plants of similar size.

Also a boiler requires make-up water to replace that lost in the steam-condensation cycle. For each of the boilers it was assumed that 20 percent of the total water requirement is lost in every condensate cycle.

MANPOWER REQUIREMENTS

The labor required to operate a boiler facility consists of operating labor, supervision, and maintenance labor. The labor requirement is based upon the number of men required to operate the boiler on a continuous (24 hour) basis. The plant is assumed to operate on a three shift basis with each man working the equivalent of 2190 hours per year. The estimates of manpower requirements reflect a conservative case with state laws that

require an operator at all times for a boiler facility taken into account. A less conservative approach could reduce these labor requirements to some extent and in cases of multiple boilers at a single site, the requirement would be significantly reduced.

BOTTOM ASH DISPOSAL REQUIREMENT

For coal-fired boilers the bottom ash disposal requirement is calculated based upon the fly ash emission factors presented in AP-42 (U.S. EPA, 1977). For each type of boiler, the percent bottom ash is as follows:

<u>Coal-firing mechanism</u>	<u>Percent bottom ash</u>
Pulverizer	20
Spreader stoker	35
Overfeed stoker	35
Chain grate stoker	75
Underfeed stoker	75
Other stokers	75

The hourly rate of bottom ash is calculated as follows:

$$\text{Bottom ash (tons/h)} = \text{Coal feed (tons/h)} \times \frac{\% \text{ ash}}{100} \times \frac{\% \text{ bottom ash}}{100}$$

For example, for the 8.8 MW thermal (30×10^6 Btu/h) package water-tube underfeed stoker boiler firing eastern high-sulfur coal the bottom ash rate is:

$$\begin{aligned} \text{Bottom ash} &= (1.27 \text{ ton/h}) (10.6 \div 100) (75 \div 100) \\ &= 0.10 \text{ ton/h} \end{aligned}$$

REFERENCES FOR SECTION 2

- Babcock & Wilcox. 1963. Steam - Its Generation and Use, Thirty-seventh Edition. New York City.
- Babcock & Wilcox. 1972. Useful Tables for Engineers and Steam Users, Twelfth Edition. New York City.
- Locklin, D.W., H.H. Krause, A.A. Putnam, E.L. Kropp, W.T. Reid, and M.A. Duffy. 1974. Design Trends and Operating Problems in Combustion Modification of Industrial Boilers. EPA R-802402, Battelle-Columbus Laboratories, Columbus, Ohio.
- U.S. EPA. 1977. Compilation of Air Pollutant Emission Factors, AP-42, Third Edition.

3.0 COST ESTIMATES FOR NEW BOILERS

Estimates were developed for the cost of new installations of the boilers described in Section 2. An outline of the procedures used in developing the costs is followed by the cost estimates.

COST ESTIMATING PROCEDURE

Cost of a boiler facility includes the costs of basic equipment, the costs of installation, and the costs of operating and maintaining the boiler. A capital cost estimate is developed by the following steps:

- ° Define the battery limits of the facility.
- ° Develop a list of equipment required.
- ° Obtain prices for each equipment item.
- ° Calculate installation costs.
- ° Calculate indirect capital costs.

Costs are all-inclusive, accounting for the material and labor needed to complete an operational boiler plant. The estimates were prepared from a detailed equipment summary. Estimates of erection costs are based on experience and on actual cost of erection at similar plants.

Battery limits of the facility extend from the fuel-receiving equipment to the ash disposal site, inclusively. Excluded are

steam and condensate piping beyond the boiler building and pollution control equipment. Costs of ducting and the stack are included.

Based on guidelines presented by H.K. Ferguson (Coffin, 1978), an equipment list was developed for each boiler. The major equipment items are described below.

Water enters the system through a treatment process--for this study a standard Zeolite softening system. The makeup water is then fed to a deaerator, which has a 15-minute holding capacity at full flow. The return condensate is piped to the condensate return tank. It is assumed that 20 percent makeup is required. The overflow storage tank for the condensate return tank is sized to hold the condensate generated in 1 hour at full load capacity.

A continuous-blowdown flash tank and drain heat recovery system recover all available heat from both the flash steam and the drains.

Two boiler feed pumps are provided, 100 percent capacity each. Automatic recirculation shutoff is not included. A fixed minimum-flow bypass orifice is used for simplicity.

Each oil-fired boiler has 100 percent Maximum Capacity Rating (MCR) oil-burning capability and includes a storage tank and transfer pump facility. In the plant, a pump and heater set are provided, consisting of two pumps (100 percent capacity) for firing of No. 6 oil. Capacity of the storage tank provides approximately 7 days firing at MCR.

Coal is stored in the plant in overhead bunkers supported by the building steel. Coal is loaded into the bunkers by a conveying system designed to fill the bunkers completely during an 8-hour shift. Bunker capacity is sufficient to operate the plant for 24 hours at full load.

The conveying system includes the under-track hopper, which supplies a coal silo with 10 days' storage; a bucket elevator or belt conveyor, depending on building height (100 ft maximum for a bucket elevator); and an over-bunker tripper conveyor to load each bunker section. A crusher included with the hopper allows some sizing of the coal feed.

The stoker-fired plants include an under-bunker conveyor, tripper mechanism, and a nonsegregating conical distributor to the stoker hopper.

The pulverized-coal-fired plant includes gravimetric feeders to the pulverizers.

Ash handling systems of the pneumatic type (dry) transport fly ash and bottom ash to a temporary storage silo for later removal by truck. The bottom ash handling equipment includes a clinker breaker.

Except for the pulverized-coal-fired boiler, which requires an air heater to dry the coal sufficiently, all boilers are equipped with economizers.

Controls are provided to regulate combustion, feedwater, and flame safety. The pulverized-coal-fired boiler also has an electronic pulverizer control system for safe and reliable starting of the pulverizers.

The building, constructed of insulated steel, includes a small office area and employees' washroom. No provision is made for an enclosed control room for the operators; rather, the boiler control panels are free-standing in front of the boiler firing aisle. Lighting, ventilation, ladders, gratings, and painting are included.

A 1 to 2 acre parcel of land is allocated to each of the boilers. Table 22 lists the basic equipment and installation items included in the capital cost estimates. Table 23 lists the sources of data used in estimating capital costs. Costs were obtained for the low-sulfur bituminous coal; costs were then apportioned to the subbituminous, medium-sulfur, and high-sulfur bituminous coals by use of factors obtained from boiler manufacturers. Indirect capital costs were estimated as a percentage of the installed equipment costs. Table 24 lists the percentages used for each item.

The costs are based on a Greenfield boiler installation with no pollution control equipment, located in the Midwest. Regional cost factors may be used to estimate costs in areas other than the Midwest. The costs were adjusted to June 30, 1978.

Annual operating and maintenance costs are based on requirements for labor, materials, and utilities as cited by manufacturers of boilers and auxiliary equipment and presented in Section 2, together with the unit costs specified for the Midwest in Table 25.

TABLE 22. BASIC EQUIPMENT AND INSTALLATION ITEMS INCLUDED
IN A NEW BOILER FACILITY

Equipment:

Boiler (with fans and ducts)
Stack
Instrumentation
Pulverizers or Stoker system
Feeders
Crushers
Deaerator
Heaters
Boiler feed pumps
Condensate systems
Water treating system
Chemical feed
Compressed air system
Coal handling system
Ash disposal system
Thawing equipment
Fuel oil system

Installation:

Foundations and supports
Piping
Insulation
Painting
Electrical
Building

TABLE 23. SOURCES OF COST DATA FOR EQUIPMENT AND INSTALLATION
ITEMS INCLUDED IN BOILER PLANTS

Equipment item	Sources of cost data
Boiler (with fans and ducts)	Babcock & Wilcox Co. Combustion Engineering, Inc. Cleaver-Brooks Division of Aqua-Chem Erie City Energy Division of Zurn E. Keeler Co.
Stacks	Airtek Rust Engineering Richardson Cost Estimating Manual ^a
Instrumentation	Aedes Associates, Inc. Babcock & Wilcox Co. Combustion Engineering, Inc. Cleaver-Brooks Division of Aqua-Chem Erie City Energy Division of Zurn E. Keeler Co.
Pulverizers or stoker system	Babcock & Wilcox Co. Combustion Engineering, Inc. Cleaver-Brooks Division of Aqua-Chem Erie City Energy Division of Zurn E. Keller Co.
Feeders	Jeffrey Manufacturing Co. Babcock & Wilcox Co. Combustion Engineering, Inc. Cleaver-Brooks Division of Aqua-Chem Erie City Energy Division of Zurn E. Keeler Co.
Crushers	Pennsylvania Crusher Co. Richardson Cost Estimating Manual ^a
Deaerator	Chicago Heater Co. Cochrane Environmental Systems
Heaters	Richardson Cost Estimating Manual
Boiler feed pumps	Ingersoll-Rand Richardson Cost Estimating Manual ^a Richardson Cost Estimating Manual ^a
(continued)	

TABLE 23. (continued)

Equipment items	Sources of cost data
Condensate system	Richardson Cost Estimating Manual ^a
Water treatment system	Crane Cochran Zeolite Calgon Corp.
Chemical feed	Milton Roy Co. Richardson Cost Estimating Manual ^a
Compressed air system	Ingersoll-Rand Richardson Cost Estimating Manual ^a
Coal handling system	Jeffrey Manufacturing Co. Caterpillar Co. Richardson Cost Estimating Manual ^a
Ash disposal system	Allen-Sherman-Hoff, Inc. United Conveyor Richardson Cost Estimating Manual ^a
Thawing equipment	Aedes Associates, Inc.
Fuel oil system	Coen Co. Aedes Associates, Inc.
Foundations and supports	Aedes Associates, Inc.
Piping	Aedes Associates, Inc.
Insulation	Aedes Associates, Inc.
Painting	Aedes Associates, Inc.
Electrical	Aedes Associates, Inc.
Building	Aedes Associates, Inc.

^a Richardson, 1978.

Table 24. TYPICAL VALUES^a FOR INDIRECT CAPITAL COSTS

Cost item	Range of values
Engineering	8 to 20 percent of installed cost. High value for small projects; low value for large projects. <u>Recommend 10 percent</u>
Construction and field expenses	7 to 20 percent of installed cost. <u>Recommend 10 percent</u>
Contractor's fee	10 to 15 percent of installed cost. <u>Recommend 10 percent</u>
Shakedown	1 to 6 percent of installed cost. <u>Recommend 2 percent</u>
Performance test	Minimum value of \$2000.
Contingency	10 to 30 percent of total direct and indirect costs dependent upon accuracy of estimate. <u>Recommend 20 percent</u>
Working capital	15 to 35 percent of the total annual operation and maintenance costs. <u>Recommend 25 percent</u>

^a Devitt, 1979.

TABLE 25. ANNUAL UNIT COSTS FOR OPERATION AND MAINTENANCE
(June 1978 dollars)

Cost factors	Recommended value
Direct labor, \$/man-hour	12.02 ^a
Supervision, \$/man-hour	15.63 ^b
Maintenance labor, \$/man-hour	14.63 ^a
Electricity, mills/kWh	25.80 ^c
Process water, \$/10 ³ gal	0.15 ^d
Coal, \$/10 ⁶ Btu	
Eastern high-sulfur	0.74 ^e
Eastern medium-sulfur	0.95 ^f
Eastern low-sulfur	1.16 ^e
Subbituminous	0.42 ^e
No. 2 fuel oil, \$/10 ⁶ Btu	3.00 ^g
No. 6 fuel oil, \$/10 ⁶ Btu	2.21 ^g
Natural gas, \$/10 ⁶ Btu	1.95 ^h
Bottom ash disposal, \$/ton	40.00 ⁱ

^a Engineering News-Record, June 29, 1978, pp. 52-52. Average for Chicago, Cincinnati, Cleveland, Detroit, and St. Louis.

^b Estimated at 30 percent over direct labor rate.

^c EEI members publication for June, 1978. Average for Boston, Chicago, Indianapolis, Houston, San Francisco, and Los Angeles.

^d Peters, M.S., and K.D. Timmerhaus. Plant Design and Economics for Chemical Engineers, 2nd Edition. McGraw-Hill Book Co. New York 1968. p. 772. Adjusted to 1978 prices using Nelson Refinery Operating Cost Indexes for Chemicals. July 1978.

^e Coal Outlook, July 18, 1978. Spot market prices.

^f Average of prices for high- and low-sulfur coal.

^g Electrical Week, May issues, 1978. Spot market prices.

^h Gas Facts, 1977. American Gas Association. Average U.S. price.

ⁱ Based on \$2/ton-mile and disposal site 20 miles from plant.

Table 26 lists the elements of annual operating and maintenance costs; Table 27 indicates the methods used in developing the costs; the boiler parameter tables (Tables 2 through 19) show the manpower requirements on which the labor costs are based.

The cost of disposing of bottom ash from a coal-fired boiler is based on a 32-km (20-mi) one-way haul to ultimate disposal in an environmentally sound landfill. The bottom ash is assumed to be wetted to 20 percent moisture and hauled in covered trucks. The disposal cost components include truck loading, washing the loaded trucks, truck transportation, road cleaning and repair, truck unloading, washing the unloaded trucks, and landfill fees, including treatment. The ash disposal operation is conducted by an outside contracting firm rather than the company itself. The waste disposal cost is estimated at \$44/Mg (\$40/ton). This is a conservative estimate of the average cost for a typical industrial boiler with a heat input of about 30 MW thermal (100×10^6 Btu/h). Although the waste disposal cost can vary greatly depending upon the haul distance and the method of disposal, this conservative estimate reflects good environmental practice.

Another component of operating cost is overhead, which represents a business expense that is not charged directly to a particular part of the process but is allocated to it. Overhead costs include administrative, safety, engineering, legal, and medical services; payroll expenses including FICA; employee benefits; and public relations. Overhead costs are usually

TABLE 26. DIRECT ANNUAL OPERATION AND MAINTENANCE COST ITEMS
ASSOCIATED WITH BOILERS

Operational labor
Supervision
Maintenance labor
Replacement parts
Electricity
Process water
Fuel
Waste disposal
Chemicals

TABLE 27. METHODS USED TO ESTIMATE DIRECT ANNUAL COSTS

Cost item	Method of obtaining cost
Operational labor	Multiply manpower requirements from parameter tables by rate given in Table 25.
Supervision	Multiply manpower requirements from parameter tables by rate given in Table 25.
Maintenance labor	Multiply manpower requirements from parameter tables by rate given in Table 25.
Replacement parts	Aedes Associates, Inc. determined percentages of total equipment cost based on actual jobs (8 to 21%).
Electricity	Based on major equipment and lighting loads.
Oil or gas-fired boilers	59 to 1453 kW
Stoker units	162 to 1001 kW
Pulverized-coal-fired units	1754 to 8920 kW
	Multiply kW by operating hours to obtain annual kWh. Multiply annual kWh by electric rate given in Table 25.
Process water	Requirement calculated assuming 80 percent return of condensate (20% make-up). Multiply annual usage by water rate given in Table 25.
Fuel	Fuel requirement calculated based on design heat input multiplied by hours per year operated based on load factors given in Tables 2 to 19. Multiply annual fuel requirement by appropriate rate from Table 25.
Waste disposal	Requirement calculated from total ash in fuel minus the quantity emitted as fly ash. Multiply the annual quantity of wash by an average cost of \$40/ton for disposal in an environmentally sound landfill 20 miles from the plant site.
Chemicals	Requirement calculated assuming constant water quality and 80 percent return of condensate (20% make-up). Multiply amount of chemicals used by average costs obtained from chemical suppliers.

presented as payroll overhead and plant overhead. Following are the values used for each:

Payroll overhead = 30 percent of operating labor

Plant overhead = 26 percent of labor and materials.

The capital investment in a boiler is generally translated into annual capital charges. These charges, along with the annual operating costs, represent the total annualized cost of a boiler.

EPA classifies annual capital-related charges for cost purposes under the following components: general and administrative costs, taxes, insurance; a capital-recovery factor, which represents a levelized principal and interest payment; and interest on working capital. The first three components are set at a total of 4 percent of depreciable investment. The capital-recovery factor was determined at 10 percent interest over the life of a facility.

Capital recovery factors are based on the following boiler life expectancies:

<u>Boiler type</u>	<u>Expected life, years</u>
Package Scotch fire-tube	20
Package water-tube	30
Field-erected water-tube	45

From these values for boiler life and the assumed interest rate of 10 percent, the capital recovery factors calculated for each boiler type are as follows:

<u>Boiler type</u>	<u>Capital recovery factor, %</u>
Package Scotch fire-tube	11.75
Package water-tube	10.61
Field-erected water-tube	10.14

COST ESTIMATES

Costs are estimated for all 59 of the typical boilers identified in Section 2. The basic boiler costs were obtained as verbal or written quotations from various boiler manufacturers including Babcock and Wilcox; Cleaver Brooks; Zurn Industries, Inc.; Erie City; and Combustion Engineering. Capital cost estimates for auxiliary equipment (e.g., water treatment systems) are based on quotations obtained from manufacturers in related projects.

The estimated costs are summarized in Table 28 for the package water-tube underfeed-stoker boilers firing the four different coal types. Detailed cost breakdowns for each of these boilers are presented in Appendix A.

The estimated costs are summarized for field-erected water-tube spreader-stoker boilers firing the four coal types in Table 29. The detailed costs are presented in Appendix A.

Table 30 summarizes the estimated costs of field-erected water-tube, pulverized-coal-fired boilers. Detailed cost breakdowns are presented in Appendix A.

The estimated costs for package fire-tube boilers are summarized in Table 31 with the detailed costs presented in Appendix B.

TABLE 28. ESTIMATED CAPITAL AND ANNUALIZED COSTS OF PACKAGE, WATER-TUBE, UNDERFEED-STOKER BOILERS FIRING COAL

Size, MW (10 ⁶ Btu/h)	Coal	Capital costs Grand total, \$	Annualized costs			Parameter table No.	Cost table
			Direct cost plus overhead less fuel, \$	Fuel Costs, \$	Capital charges, \$		
4.4 (15)	Eastern high-sulfur	1,245,000	469,900	58,300	176,900	2	A-1, A-2
4.4 (15)	Eastern low-sulfur	1,094,600	453,300	1,500	154,700	2	A-3, A-4
4.4 (15)	Subbituminous	1,487,300	485,100	33,100	212,500	2	A-5, A-6
4.4 (15)	Eastern medium-sulfur	1,133,200	462,800	74,900	160,500	2	A-7, A-8
8.8 (30)	Eastern high-sulfur	1,891,300	565,800	116,700	269,800	3	A-9, A-10
8.8 (30)	Eastern low-sulfur	1,665,200	538,700	182,900	236,300	3	A-11, A-12
8.8 (30)	Subbituminous	2,257,100	587,100	66,200	323,600	3	A-13, A-14
8.8 (30)	Eastern medium-sulfur	1,723,000	554,000	149,800	244,900	3	A-15, A-16
17.6 (60)	Eastern high-sulfur	3,021,800	847,000	233,400	431,100	4	A-17, A-18
17.6 (60)	Eastern low-sulfur	2,670,700	802,000	365,800	378,600	4	A-19, A-20
17.6 (60)	Subbituminous	3,594,100	873,400	132,500	515,600	4	A-21, A-22
17.6 (60)	Eastern medium-sulfur	2,758,100	832,000	299,600	391,900	4	A-23, A-24

TABLE 29. ESTIMATED CAPITAL AND ANNUALIZED COSTS OF FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILERS FIRING COAL

Size, MW (10 ⁶ Btu/h)	Coal	Capital costs Grand total, \$	Annualized costs			Parameter table No.	Cost table
			Direct cost plus overhead less fuel, \$	Fuel Costs, \$	Capital charges, \$		
22.0 (75)	Eastern high-sulfur	4,587,700	898,800	291,700	638,300	5	A-25, A-26
22.0 (75)	Eastern low-sulfur	4,064,200	858,500	457,100	563,100	5	A-27, A-28
22.0 (75)	Subbituminous	5,440,700	935,600	165,600	760,000	5	A-29, A-30
22.0 (75)	Eastern medium-sulfur	4,192,200	878,800	374,500	581,700	5	A-31, A-32
44.0 (150)	Eastern high-sulfur	8,784,200	1,265,700	583,400	1,225,900	6	A-33, A-34
44.0 (150)	Eastern low-sulfur	7,804,100	1,187,300	914,500	1,084,500	6	A-35, A-36
44.0 (150)	Subbituminous	10,195,800	1,334,300	331,100	1,455,700	6	A-37, A-38
44.0 (150)	Eastern medium-sulfur	8,041,900	1,229,000	749,000	1,119,500	6	A-39, A-40
58.6 (200)	Eastern high-sulfur	10,510,200	1,641,000	777,900	1,465,000	7	A-41, A-42
58.6 (200)	Eastern low-sulfur	9,155,200	1,541,900	1,219,400	1,298,000	7	A-43, A-44
58.6 (200)	Subbituminous	12,411,400	1,731,700	441,500	1,736,500	7	A-45, A-46
58.6 (200)	Eastern medium-sulfur	9,637,500	1,596,200	998,600	1,339,700	7	A-47, A-48

TABLE 30. ESTIMATED CAPITAL AND ANNUALIZED COSTS OF FIELD-ERECTED, WATER-TUBE, PULVERIZED-COAL-FIRED BOILERS

Size, MW (10 ⁶ Btu/h)	Coal	Capital costs Grand total, \$	Annualized costs				Parameter table No.	Cost table
			Direct cost plus overhead less fuel, \$	Fuel Costs, \$	Capital charges, \$	Total, \$		
58.6 (200)	Eastern high-sulfur	12,202,400	1,766,900	777,900	1,702,900	4,247,700	8	A-49, A-50
58.6 (200)	Eastern low-sulfur	10,823,200	1,656,200	1,219,400	1,504,400	4,380,000	8	A-51, A-52
58.6 (200)	Subbituminous	14,468,400	1,901,500	441,500	2,025,600	4,368,600	8	A-53, A-54
58.6 (200)	Eastern medium-sulfur	11,161,500	1,701,400	998,600	1,554,100	4,254,100	8	A-55, A-56
117.2 (400)	Eastern high-sulfur	22,618,000	3,068,300	1,555,800	3,159,500	7,783,600	9	A-57, A-58
117.2 (400)	Eastern low-sulfur	20,094,000	2,878,200	2,438,800	2,792,500	8,109,500	9	A-59, A-60
117.2 (400)	Subbituminous	26,836,600	3,288,800	883,000	3,758,200	7,930,000	9	A-61, A-62
117.2 (400)	Eastern medium-sulfur	20,707,300	2,960,700	1,997,000	2,883,000	7,840,700	9	A-63, A-64
205.1 (700)	Eastern high-sulfur	36,490,200	4,200,000	2,722,600	5,096,800	12,019,400	10	A-65, A-66
205.1 (700)	Eastern low-sulfur	32,369,200	3,912,500	4,267,900	4,500,900	12,681,300	10	A-67, A-68
205.1 (700)	Subbituminous	43,060,300	4,509,900	1,545,300	6,035,000	12,090,200	10	A-69, A-70
205.1 (700)	Eastern medium-sulfur	33,302,400	4,044,300	3,495,200	4,639,500	12,179,000	10	A-71, A-72

TABLE 31. ESTIMATED CAPITAL AND ANNUALIZED COSTS OF PACKAGE, FIRE-TUBE BOILERS

Size MW (10 ⁶ Btu/h)	Fuel	Capital costs grand total, \$	Annualized costs				Parameter table No.	Cost table
			Direct cost plus overhead less fuel, \$	Fuel cost, \$	Capital charges, \$	Total, \$		
1.5 (5)	Residual oil	243,700	201,300	43,600	35,500	280,400	11	B-1, B-2
4.4 (15)	Residual oil	404,200	322,400	130,700	58,100	511,200	11	B-3, B-4
8.5 (29)	Residual oil	602,500	347,800	252,600	87,200	687,600	11	B-5, B-6
1.5 (5)	Distillate oil	241,800	201,300	59,100	34,900	295,300	12	B-7, B-8
4.4 (15)	Distillate oil	404,800	322,400	177,400	57,600	557,400	12	B-9, B-10
8.5 (29)	Distillate oil	610,900	347,800	343,000	87,300	778,100	12	B-11, B-12
1.5 (5)	Natural gas	236,600	201,300	38,400	34,400	274,100	13	B-13, B-14
4.4 (15)	Natural gas	389,300	322,400	115,300	56,000	493,700	13	B-15, B-16
8.5 (29)	Natural gas	580,900	347,800	222,900	84,300	655,000	13	B-17, B-18

Estimated costs of dual-fuel water-tube boilers firing residual oil/natural gas are summarized in Table 32 with detailed costs presented in Appendix C. Table 33 summarizes the estimated costs of dual-fuel water-tube boilers firing distillate oil/natural gas. Detailed costs are presented in Appendix C.

TABLE 32. ESTIMATED CAPITAL AND ANNUALIZED COSTS OF DUAL-FUEL, WATER-TUBE BOILERS FIRING RESIDUAL OIL/NATURAL GAS

Boiler type	Size, MW (10 ⁶ Btu/h)	Capital costs		Annualized costs					Parameter tables (oil/gas)	Cost tables
		Grand total, \$ (oil/gas)	Direct cost plus overhead less fuel, \$ (oil/gas)	Fuel Costs, \$ (oil/gas)	Capital charges, \$ (oil/gas)	Total, \$ (oil/gas)				
Package	8.8 (30)	802,900/ 793,500	359,400	319,400/ 281,900	110,300/ 109,300	789,100/ 750,600	14/16	C-1, C-2		
Package	17.6 (60)	1,230,500/ 1,211,700	420,200	630,900/ 563,700	168,500/ 166,600	1,227,600/ 1,150,500	14/16	C-3, C-4		
Package	29.3 (100)	1,734,000/ 1,702,700	520,800	1,064,800/ 939,500	236,300/ 233,200	1,821,900/ 1,693,500	14/16	C-5, C-6		
Package	44.0 (150)	2,276,600/ 2,229,600	625,900	1,597,200/ 1,409,300	308,600/ 303,900	2,531,700/ 2,339,100	14/16	C-7, C-8		
Field-erected	58.6 (200)	7,412,000/ 7,349,300	868,100	2,129,600/ 1,879,000	1,019,100/ 1,012,900	4,016,800/ 3,760,000	17/19	C-9, C-10		
Field-erected	117.2 (400)	13,225,900/ 13,100,600	1,393,700	4,259,100/ 3,758,000	1,815,300/ 1,802,800	7,468,100/ 6,954,500	17/19	C-11, C-12		
Field-erected	205.1 (700)	21,331,400/ 21,112,200	1,898,300	7,453,400/ 6,576,600	2,924,300/ 2,902,400	12,276,000/ 11,377,300	17/19	C-13, C-14		

TABLE 33. ESTIMATED CAPITAL AND ANNUALIZED COSTS OF DUAL-FUEL, WATER-TUBE BOILERS FIRING DISTILLATE OIL/NATURAL GAS

Boiler type	Size, MM (10 ⁶ Btu/h)	Capital costs Grand total, \$ (oil/gas)	Annualized costs				Parameter tables (oil/gas)	Cost tables
			Direct cost plus overhead less fuel, \$ (oil/gas)	Fuel costs, \$ (oil/gas)	Capital charges, \$ (oil/gas)	Total, \$ (oil/gas)		
Package	8.8 (30)	817,200/ 779,300	359,400	433,600/ 281,900	111,000/ 107,200	904,000/ 748,500	15/16	C-15, C-16
Package	17.6 (60)	1,267,000/ 1,191,100	420,200	867,200/ 563,700	171,200/ 163,600	1,458,600/ 1,147,500	15/16	C-17, C-18
Package	29.3 (100)	1,806,500/ 1,680,000	520,800	1,445,400/ 939,500	242,600/ 229,900	2,208,800/ 1,690,200	15/16	C-19, C-20
Package	44.0 (150)	2,393,900/ 2,204,200	625,900	2,168,100/ 1,409,300	319,200/ 300,200	3,113,200/ 2,335,400	15/16	C-21, C-22
Field-erected	58.6 (200)	7,483,500/ 7,230,500	868,100	2,890,800/ 1,879,000	1,021,300/ 996,000	4,780,200/ 3,743,100	18/19	C-23, C-24
Field-erected	117.2 (400)	13,379,900/ 12,874,000	1,393,700	5,781,600/ 3,758,800	1,821,300/ 1,770,700	8,996,600/ 6,922,400	18/19	C-25, C-26
Field-erected	205.1 (700)	21,609,400/ 20,724,100	1,898,300	10,117,800/ 6,576,400	2,935,900/ 2,847,400	14,952,000/ 11,322,300	18/19	C-27, C-28

REFERENCES FOR SECTION 3

- Coffin, B.D. 1978. Costing Examples of Industrial Applications, coal-fired Boiler Plants. H.K. Ferguson Co., Cleveland, Ohio.
- Richardson Engineering Services, Inc. 1978. Process Plant Construction Estimating and Engineering Standards. Solana Beach, California.
- Devitt, T., P. Spaite, and L. Gibbs. 1979. The Population and Characteristics of Industrial/Commercial Boilers. PEDCo Environmental, Inc., Cincinnati, Ohio.

4.0 EQUATIONS FOR BOILER COSTS

In order to obtain costs for use by OAQPS in the overall economic evaluation of various regulatory options on new boiler installations, it was necessary to develop relationships between boiler capacity, fuel, and costs. In this task, equations were developed to describe the costs of package fire-tube boilers firing a variety of fuels, package water-tube boilers firing a variety of fuels, and field-erected water-tube boilers also firing a variety of fuels. The following sections present the methodology used in deriving these equations and the results of the analysis.

METHODOLOGY

The basic steps involved in deriving new boiler cost equations were:

- Detailed cost estimates
- Segmenting costs into appropriate categories
- Plotting costs versus input capacity
- Determination of cost equation form
- Derivation of cost equation

Detailed Cost Estimates

Detailed cost estimates were made for the 51 boiler/fuel/capacity combinations described previously. In addition, from previous work, 8 detailed cost estimates were available.

Segmenting Costs Into Appropriate Categories

In this study, equations were to be derived to describe five major components of costs including equipment cost, direct installation costs, indirect installation costs, variable annual operating and maintenance costs, and nonvariable annual operating costs.

The equipment cost, direct installation costs, and indirect installation costs are presented as subtotals in each detailed boiler cost breakdown. Table 34 lists all items included in each subtotal. Note that contingencies, land, and working capital have been excluded from the cost equations. This allows the reader to use site-specific values. For the coal-fired boilers, some of the equipment and direct installation cost items also vary dependent upon the type of coal being burned. Table 34 also indicates the items which vary with coal types.

The direct cost and overhead components of annual cost were classified as either variable (dependent upon the period of time the boiler operated) or non-variable (independent of boiler operational time). Table 35 shows the items classified as variable or nonvariable. It should be noted that although fuel is shown as a variable cost item, for purposes of this study this cost was excluded from the cost equations because the fuel cost can be calculated separately as a direct product of fuel price and fuel usage. Capital charges have also been excluded.

Plotting Costs Versus Input Capacity

The next step was to plot the costs in each category against boiler input capacity by major boiler type/fuel classification. For example, equipment costs for the three residual oil-fired fire-tube boilers were plotted against the appropriate heat input

TABLE 34. FORMAT FOR PRESENTATION OF CAPITAL COSTS
OF INDUSTRIAL BOILERS

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST

Boiler (with fans & ducts)	Variable
Stack	
Instrumentation	
Pulverizers or stokers	Variable
Feeders	Variable
Crushers	Variable
Deaerators	
Heaters	
Boiler feed pumps	
Condensate systems	
Water treating system	
Chemical feed	
Compressed air system	Variable
Coal handling system	Variable
Ash disposal system	Variable
Thawing equipment	
Fuel-oil system	

Total Equipment Cost

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	Variable
Stack	
Instrumentation	
Pulverizers	Variable
Feeders	Variable
Crushers	Variable
Deaerators	
Heaters	
Boiler feed pumps	
Condensate system	
Water treating system	
Chemical feed	
Coal handling system	Variable
Ash disposal system	Variable
Thawing equipment	
Fuel-oil system	

N.A. - Not applicable.
(continued)

TABLE 34. (continued)

INSTALLATION COSTS, DIRECT (cont.)	
Foundations and supports	<u>Variable</u>
Ductwork (not incl. w/boiler)	<u>Variable</u>
Piping	<u>Variable</u>
Insulation	<u>Variable</u>
Painting	<u>Variable</u>
Electrical	<u>Variable</u>
Buildings	<u>Variable</u>
Total installation cost	<u> </u>
TOTAL DIRECT COSTS (equipment + installation)	<u> </u>
INSTALLATION COSTS, INDIRECT	
Engineering (10% of direct costs)	<u> </u>
Construction and field expense (10% of direct costs)	<u> </u>
Construction fees (10% of direct costs)	<u> </u>
Start-up (2% of direct costs)	<u> </u>
Performance tests (minimum \$2000)	<u> </u>
TOTAL INDIRECT COSTS	<u> </u>
Contingencies (20% of direct and indirect costs)	<u>N/A</u>
Total Turnkey Costs (direct+indirect+contingencies)	<u>N/A</u>
Land	<u>N/A</u>
Working capital (25% of total direct operating costs)	<u>N/A</u>
GRAND TOTAL (turnkey+land+working capital)	<u>N/A</u>

N/A - Not applicable.

TABLE 35. FORMAT FOR PRESENTATION OF ANNUALIZED COSTS
OF INDUSTRIAL BOILERS

DIRECT COST

Direct labor	<u>Non-variable</u>
Supervision	<u>Non-variable</u>
Maintenance labor	<u>Non-variable</u>
Maintenance materials	<u>Non-variable</u>
Replacement parts	<u>Non-variable</u>
Electricity	<u>Variable</u>
Steam	<u>Variable</u>
Cooling water	<u>Variable</u>
Process water	<u>Variable</u>
Fuel	<u>Variable^a</u>
Bottom ash disposal	<u>Variable</u>
Chemicals	<u>Variable</u>
Total direct cost	<u>Variable</u>

OVERHEAD

Payroll (30% of direct labor	<u>Non-variable</u>
Plant (26% of labor, parts & maint.)	<u>Non-variable</u>
Total overhead costs	<u>Non-variable</u>

BY-PRODUCT CREDITS

N/A

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	<u>N/A</u>
Capital recovery factor (% of total turnkey costs)	<u>N/A</u>
Interest on working capital (10% of working capital)	<u>N/A</u>
Total capital charges	<u>N/A</u>

TOTAL ANNUALIZED COSTS

N/A

^a Not included in the equations.

N.A. - Not applicable.

capacities (i.e. 5, 15, and 29 x 10⁶ Btu/h). This step was followed for all major boiler-fuel types including plots for residual oil-fired fire-tube, distillate oil-fired fire-tube, natural gas-fired fire-tube, stoker coal-fired package water-tube, residual oil/natural gas-fired package water-tube, distillate oil/natural gas-fired package water-tube, stoker coal-fired field-erected water-tube, pulverized coal-fired field-erected water-tube, residual oil/natural gas-fired field-erected water-tube, and distillate oil/natural gas-fired field-erected water-tube.

Determination of Cost Equation Form

Each plot is then examined to determine the approximate form of the cost equation. If the plot is a straight line, the equation is a simple binomial of the form $y = ax + b$ where a and b are constants. If the plot is curved, the points are replotted on log-log scales and on semi-log scales. If the plot on log-log scales is a straight line, the equation is of the form $y = ax^b$, where a and b are constants. If the plot on semi-log scales is a straight line, the equation will be of the form $y = ab^{cx}$, where a , b , and c are constants.

Derivation of Cost Equation

Depending upon which equation exhibits the best fit, a regression analysis is performed via a computer program which will determine the values of the constants for each equation form.

Boiler Cost Equation Results

The cost equations for the package water-tube underfeed stoker boilers are presented in Table 36. Equations for field-erected water-tube spreader stoker boilers are presented in Table 37. Table

TABLE 36. COST EQUATIONS FOR PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILERS^{a,b,c,d,e,f,g}

Equipment cost

$$y = 66,392x^{0.622} (11,800/z) + 2257x^{0.819}$$

Direct installation cost

$$y = 53,219x^{0.65} (11,800/z) + 2882x^{0.796}$$

Indirect installation cost

$$y = 40,188x^{0.646} (11,800/z)^{0.926}$$

Variable annual operating cost^h

$$y = [6012x^{0.689} (11,800/z)^{0.9} (A/10.6)^{0.3}] (H/5256)$$

Nonvariable annual costⁱ

$$y = [308,900 + 7176x] (11,800/z)^{0.166}$$

^a x = heat input rate (10^6 Btu/h)

^b y = actual cost (\$)

^c z = heating value of coal (Btu/lb)

^d A = ash content of coal (%)

^e H = equivalent hours operated per year at maximum capacity.

^f Costs are in June 1978 dollars.

^g Applicable to heat inputs ranging from 15 to 60×10^6 Btu/h.

^h Does not include fuel cost.

ⁱ Excludes capital charges.

TABLE 37. COST EQUATIONS FOR FIELD-ERECTED,
WATER-TUBE, SPREADER-STOKER BOILERS^{a,b,c,d,e,f,g}

Equipment cost (size $\leq 150 \times 10^6$ Btu/h)
$y = 25,052x^{0.906} (11,800/z) + 4,626x^{0.868}$
Equipment cost (size $> 150 \times 10^6$ Btu/h)
$y = 25,052x^{0.906} (11,800/z) + 14,205x^{0.714}$
Direct installation cost (size $\leq 150 \times 10^6$ Btu/h)
$y = 45,468x^{0.757} (11,800/z) + 2,919x^{0.869}$
Direct installation cost (size $> 150 \times 10^6$ Btu/h)
$y = 45,468x^{0.757} (11,800/z) + 9464x^{0.647}$
Indirect installation cost
$y = 21,154x^{0.867} (11,800/z)^{0.86}$
Variable annual operating cost ^h
$y = 3,566x^{0.743} (11,800/z) (A/10.6)^{0.3} (\frac{H}{5256})$
Nonvariable annual cost ⁱ
$y = 66,924x^{0.574} (11,800/z)^{0.188}$

^a x = heat input rate (10^6 Btu/h)

^b y = actual cost (\$)

^c z = heating value of coal (Btu/lb)

^d A = ash content of coal (%)

^e H = equivalent hours operated per year at maximum capacity.

^f Costs are in June 1978 dollars.

^g Applicable to heat inputs ranging from 75 to 200×10^6 Btu/h.

^h Does not include fuel cost.

ⁱ Excludes capital charges.

38 presents cost equations for field-erected, water-tube, pulverized-coal-fired boilers. The cost equations for package fire-tube boilers are presented in Table 39. In Table 40 are presented cost equations for dual-fuel water-tube boilers firing residual oil/natural gas. The cost equations for dual-fuel water-tube boilers firing distillate oil/natural gas are presented in Table 41.

The algorithms are varied in form from boiler to boiler and from fuel to fuel. The equations are an approximation of the way the actual costs of boilers vary with size, fuel, and type. The equations are composites of the costs of many components that do not vary in the same manner between sizes, boiler types, and fuels. However, comparisons of costs derived from the equations to detailed costs presented in the appendices, show that the equations give costs at least within 8 percent of the detailed cost estimates.

Plots of Various Detailed Cost Items Versus Heat Input Design Capacity

Plots of different detailed cost items versus heat input have been included. The primary advantage of the plots is that cost trends are more readily observed than by examination of the algorithms or detailed cost estimates. They are also useful in comparing costs of different boiler types.

Figures 1, 2, and 3 provide the equipment costs of boilers with fans and ducts versus heat input. Plots of total turnkey costs versus heat input are shown in Figures 4 through 8. Figures 9 through 11 show operating and maintenance costs (direct cost plus overhead less fuel cost) versus equivalent hours of operation per year at maximum capacity for selected boilers.

TABLE 38. COST EQUATIONS FOR FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILERS^{a,b,c,d,e,f,g}

Equipment cost

$$y = [904,426 + 14,564x] (11,800/z) + 92,079 + 3,107x$$

Direct installation cost

$$y = 24,019x^{0.886} (11,800/z) + 17,395 + 1,254x$$

Indirect installation cost

$$y = 22,782x^{0.877} (11,800/z)^{0.87}$$

Variable annual operating cost^h

$$y = 1,586x^{1.006} (11,800/z)^{0.9} (A/10.6)^{0.13} \left(\frac{H}{5256}\right)$$

Nonvariable annual costⁱ

$$y = 60,380x^{0.604} \left(\frac{11,800}{z}\right)^{0.26}$$

^a x = heat input rate (10^6 Btu/h)

^b y = actual cost (\$)

^c z = heating value of coal (Btu/lb)

^d A = ash content of coal (%)

^e H = equivalent hours operated per year at maximum capacity.

^f Costs are in June 1978 dollars.

^g Applicable to heat inputs ranging from 200 to 700×10^6 Btu/h.

^h Does not include fuel cost.

ⁱ Excludes capital charges.

TABLE 39. COST EQUATIONS FOR PACKAGE
FIRE-TUBE BOILERS^{a,b,c,d,e}

Residual Oil-Fired	
Equipment cost	$y = 17,360x^{0.557}$
Direct installation cost	$y = 4324x + 56,177$
Indirect installation cost	$y = 2317x + 29,749$
Variable annual operating cost ^f (heat input $\leq 15 \times 10^6$ Btu/h)	$y = [580x + 3900] (H/3942)$
Variable annual operating cost ^f (heat input $>15 \times 10^6$ Btu/h)	$y = [914x - 1114] (H/3942)$
Nonvariable annual cost ^g (heat input $\leq 15 \times 10^6$ Btu/h)	$y = 11,530x + 136,850$
Nonvariable annual cost ^g (heat input $>15 \times 10^6$ Btu/h)	$y = 900x + 296,300$
Natural Gas-Fired or Distillate Oil-Fired	
Equipment cost	$y = 15,981x^{0.561}$
Direct installation cost	$y = 4261x + 56,041$
Indirect installation cost	$y = 2256x + 28,649$
Variable annual operating cost ^f (heat input $\leq 15 \times 10^6$ Btu/h)	$y = [580x + 3900] (H/3942)$
Variable annual operating cost ^f (heat input $>15 \times 10^6$ Btu/h)	$y = [914x - 1114] (H/3942)$
Nonvariable annual cost ^g (heat input $\leq 15 \times 10^6$ Btu/h)	$y = 11,530x + 136,850$
Nonvariable annual cost ^g (heat input $>15 \times 10^6$ Btu/h)	$y = 900x + 296,300$

^a x = heat input rate (10^6 Btu/h).

^b y = actual cost (\$).

^c H = equivalent hours operated
per year at maximum capacity.

^d Costs in June 1978 dollars.

^e Applicable to heat inputs
ranging from 1 to 30×10^6 Btu/h.

^f Does not include fuel cost.

^g Excludes capital charges.

TABLE 40. COST EQUATIONS FOR WATER-TUBE, DUAL-FUEL
BOILERS FIRING RESIDUAL OIL/NATURAL GAS^{a,b,c,d}

Package Units ^e	
Equipment cost	$y = 15,925x^{0.775}$
Direct installation cost	$y = 54,833x^{0.364}$
Indirect installation cost	$y = 16,561x^{0.613}$
Variable annual operating cost ^f	$y = [202x + 24,262] (H/4818)$
Nonvariable annual cost ^g	$y = 2048x + 266,078$
Field-Erected Units ^h	
Equipment cost	$y = 8602x + 714,824$
Direct installation cost	$y = 18,427x^{0.866}$
Indirect installation cost	$y = 16,306x^{0.835}$
Variable annual operating cost ^f	$y = [269x + 25,884] (H/4818)$
Nonvariable annual cost ^g	$y = 31,628x^{0.61}$

^a x = heat input rate (10^6 Btu/h).

^b y = actual cost (\$).

^c H = equivalent hours operated per year at maximum capacity.

^d Costs in June 1978 dollars.

^e Applicable to heat inputs ranging from 30 to 150×10^6 Btu/h.

^f Does not include fuel cost.

^g Excludes capital charges.

^h Applicable to heat input ranging from 200 to 700×10^6 Btu/h.

TABLE 41. COST EQUATIONS FOR WATER-TUBE, DUAL-FUEL
BOILERS FIRING DISTILLATE OIL/NATURAL GAS^{a,b,c,d}

Package Units ^e	
Equipment cost	$y = 14,850x^{0.786}$
Direct installation cost	$y = 54,620x^{0.361}$
Indirect installation cost	$y = 15,952x^{0.618}$
Variable annual operating cost ^f	$y = [202x + 24,262] (H/4818)$
Nonvariable annual cost ^g	$y = 2048x + 266,078$
Field-Erected Units ^h	
Equipment cost	$y = 8372x + 711,271$
Direct installation cost	$y = 18,262x^{0.865}$
Indirect installation cost	$y = 4812x + 431,779$
Variable annual operating cost ^f	$y = [269x + 25,884] (H/4818)$
Nonvariable annual cost ^g	$y = 31,628x^{0.61}$

^a x = heat input rate (10^6 Btu/h).

^b y = actual cost (\$).

^c H = equivalent hours operated per year at maximum capacity.

^d Costs in June 1978 dollars.

^e Applicable to heat inputs ranging from 30 to 150×10^6 Btu/h.

^f Does not include fuel cost.

^g Excludes capital charges.

^h Applicable to heat input ranging from 200 to 700×10^6 Btu/h.

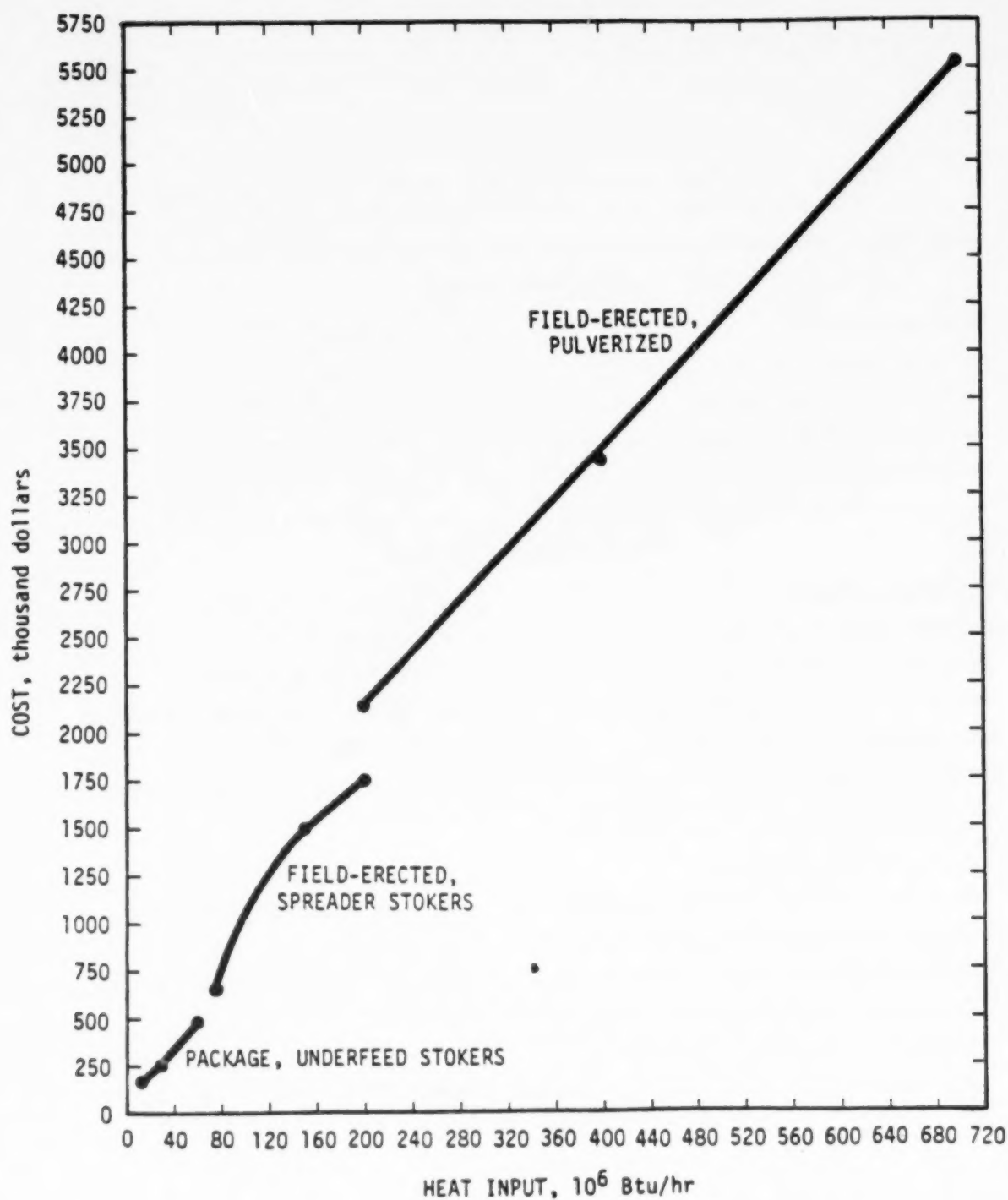


Figure 1. Equipment costs of water-tube boilers (with fans and ducts) firing eastern low-sulfur coal versus heat input.

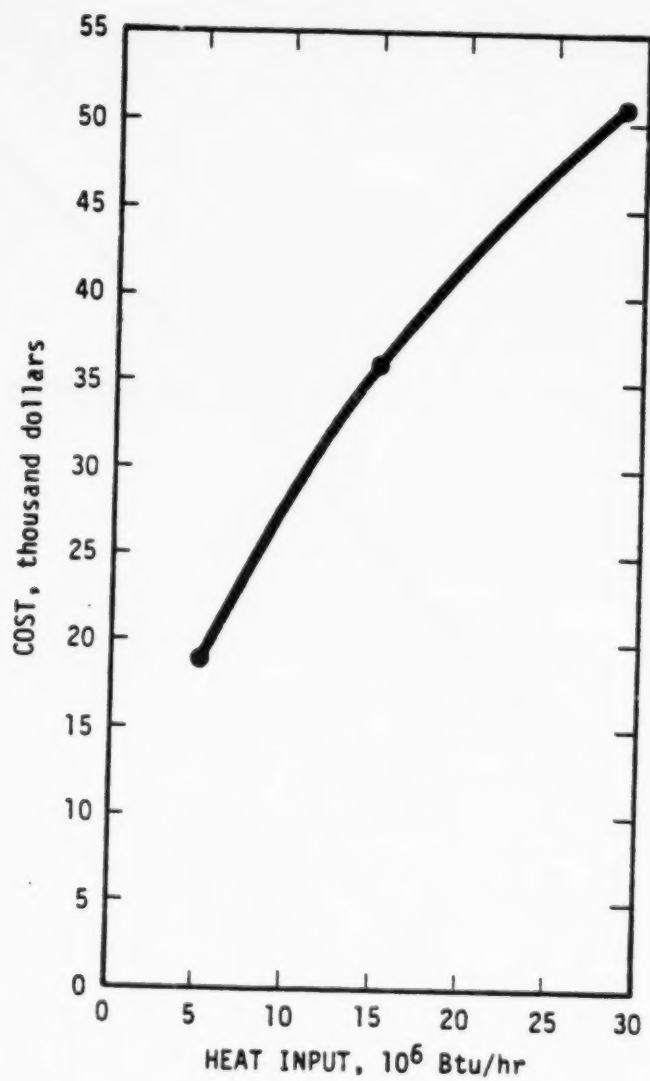


Figure 2. Equipment costs of package, fire-tube boilers (with fans and ducts) firing residual oil, distillate oil or natural gas versus heat input.

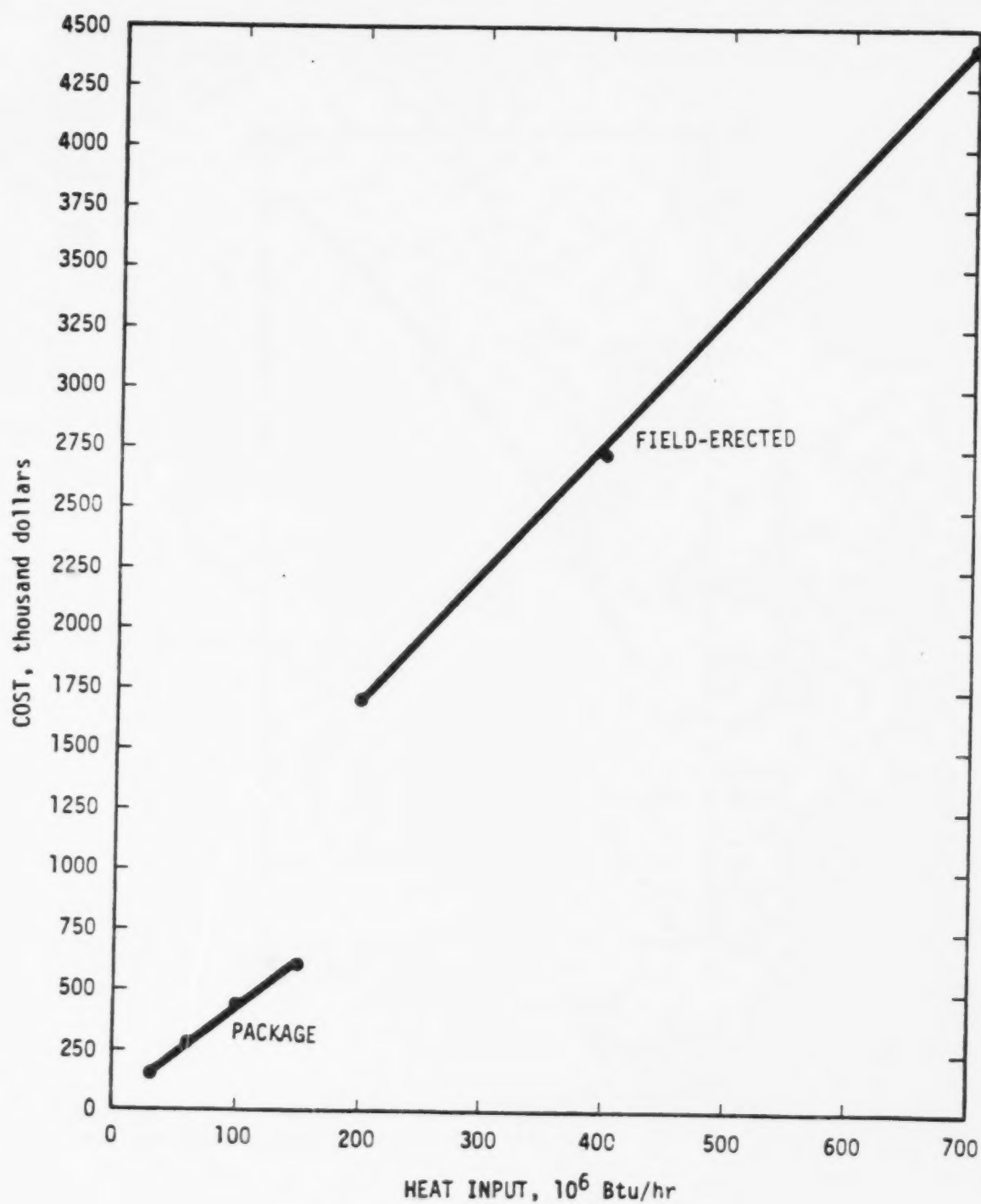


Figure 3. Equipment costs of dual-fuel, water-tube boilers (with fans and ducts) firing residual oil/natural gas or distillate oil/natural gas versus heat input.

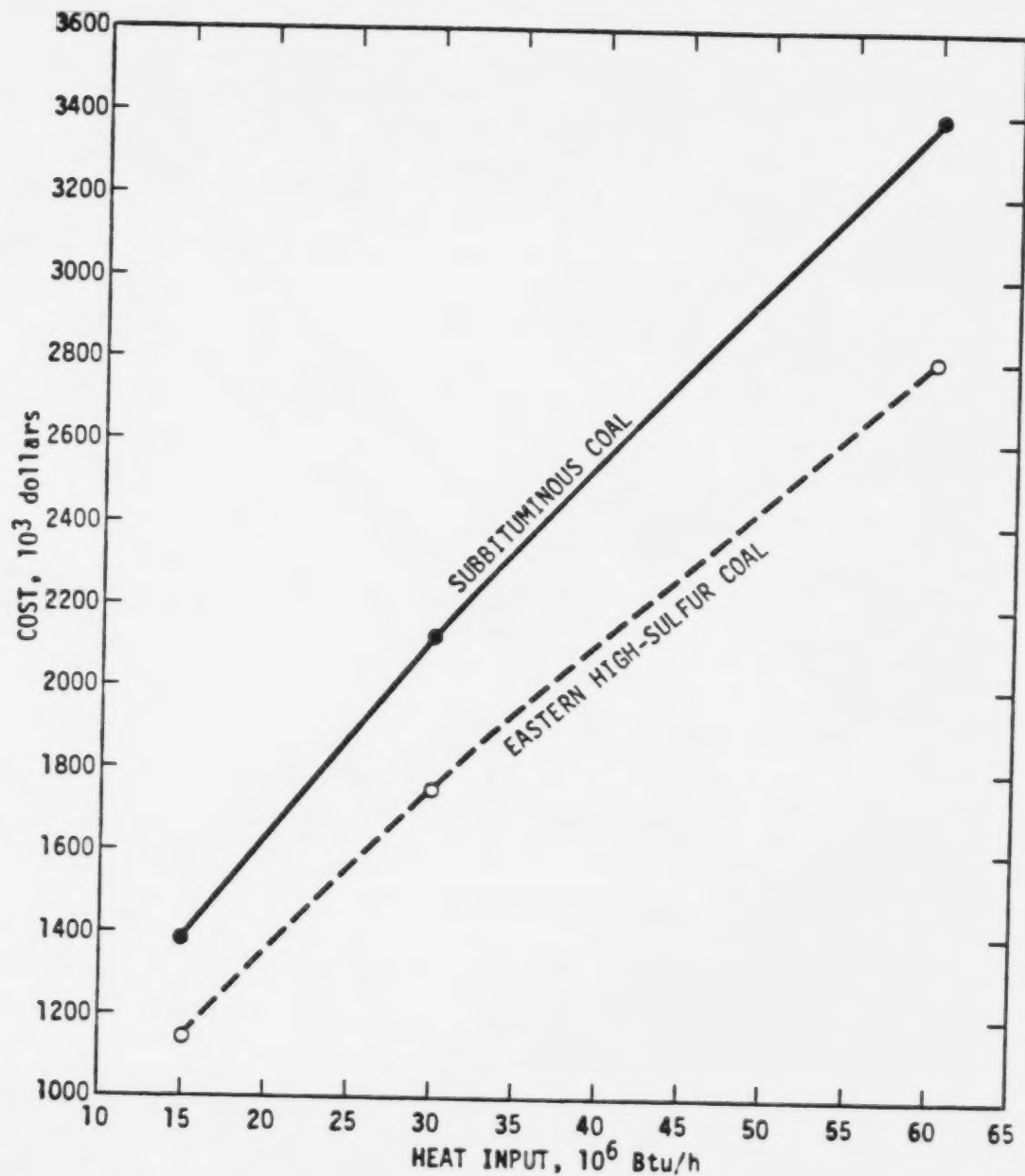


Figure 4. Total turnkey costs of coal-fired, package, underfeed-stoker boilers firing eastern high-sulfur coal or subbituminous coal versus heat input.

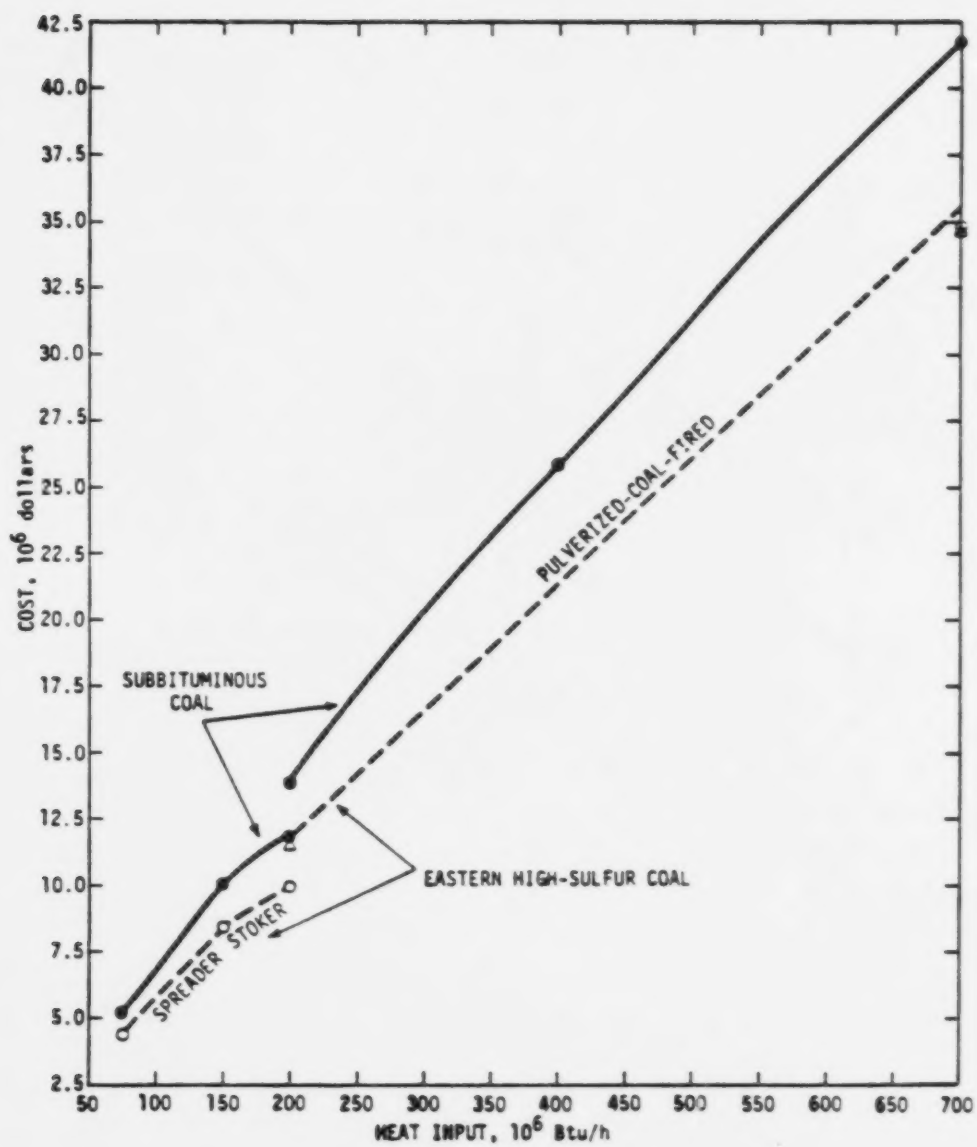


Figure 5. Total turnkey costs of coal-fired, field-erected boilers firing eastern high sulfur coal or subbituminous coal versus heat input.

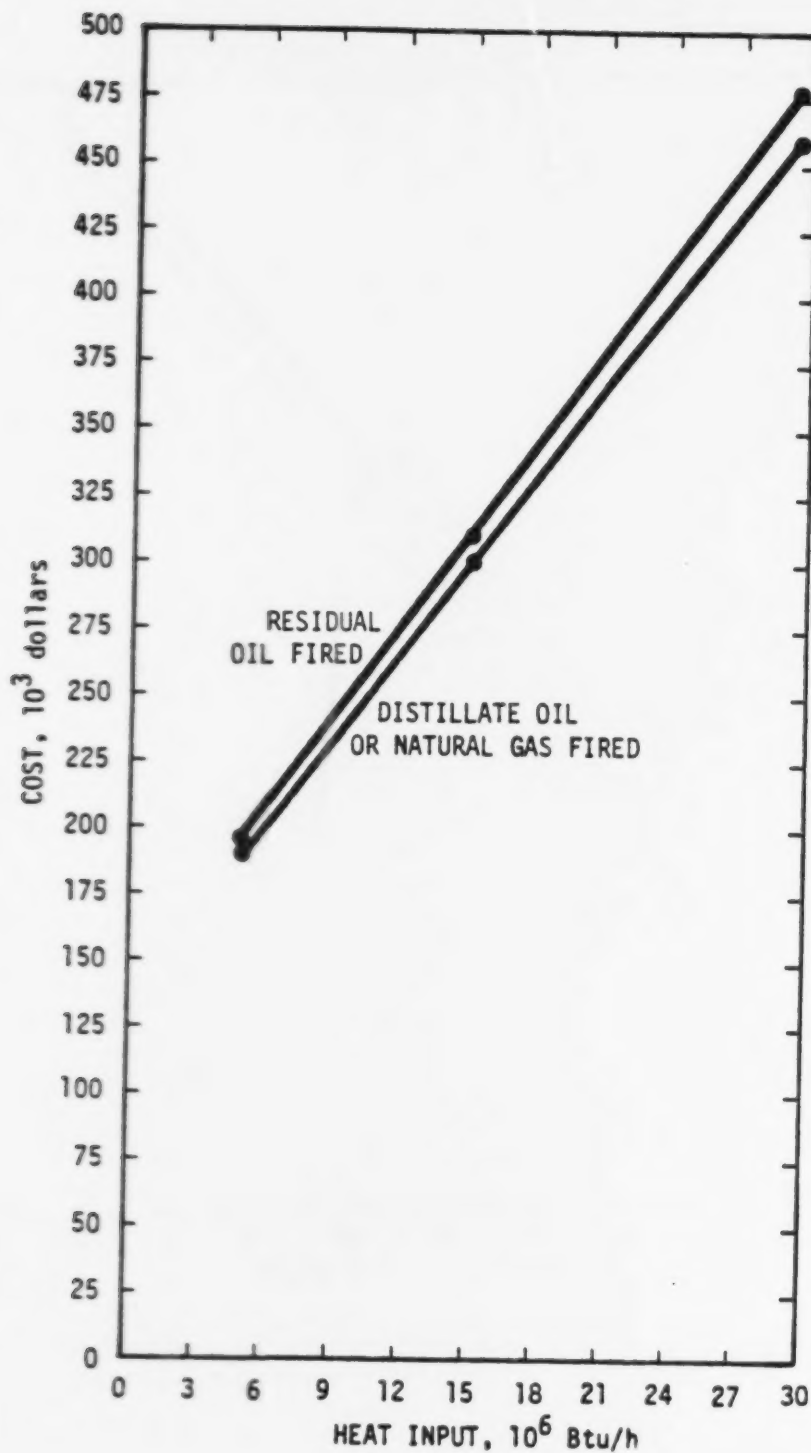


Figure 6. Total turnkey costs of package, fire-tube boilers firing residual oil, distillate oil, or natural gas versus heat input.

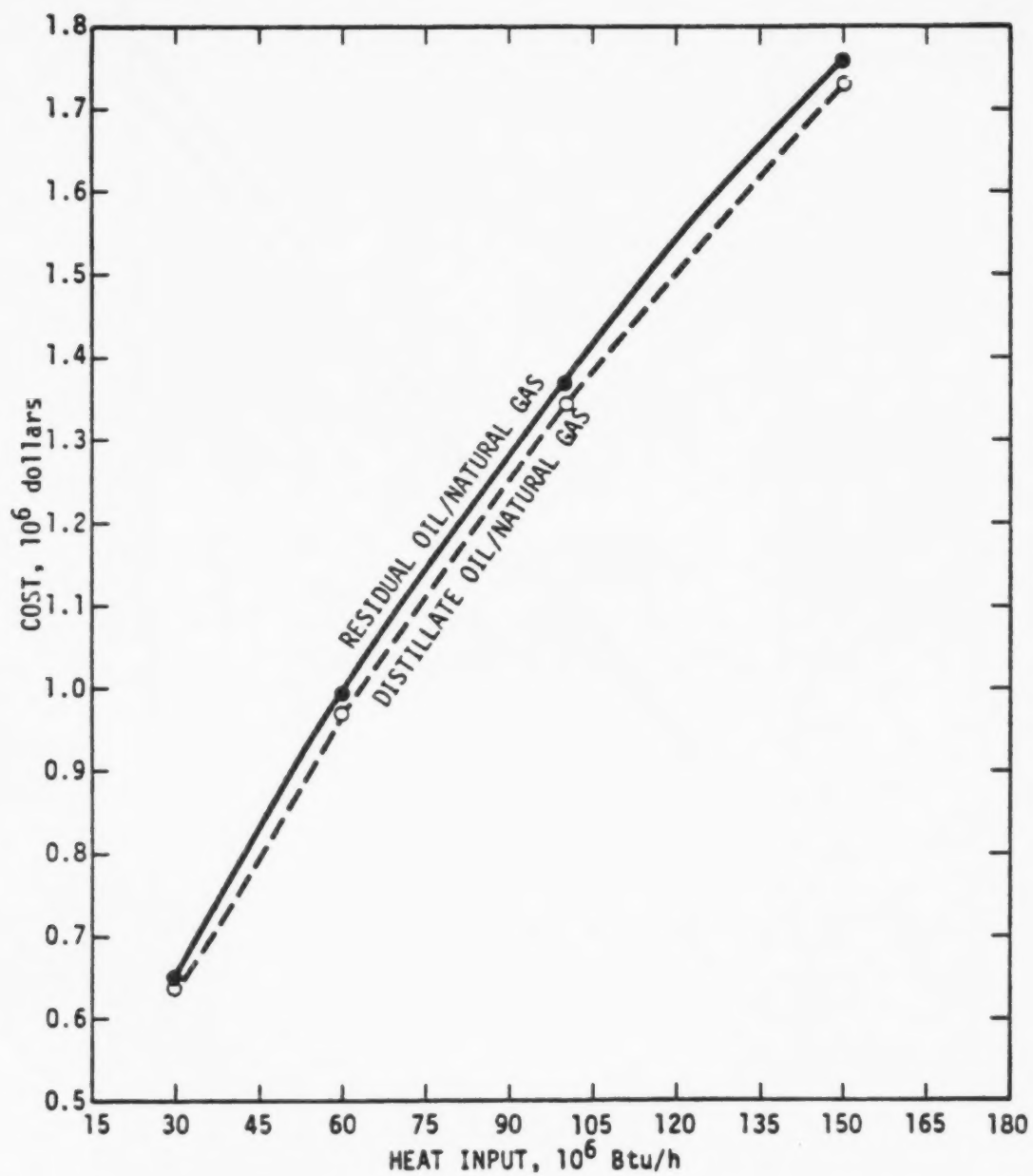


Figure 7. Total turnkey costs of dual-fuel, package boilers firing residual oil/natural gas or distillate oil/natural gas versus heat input.

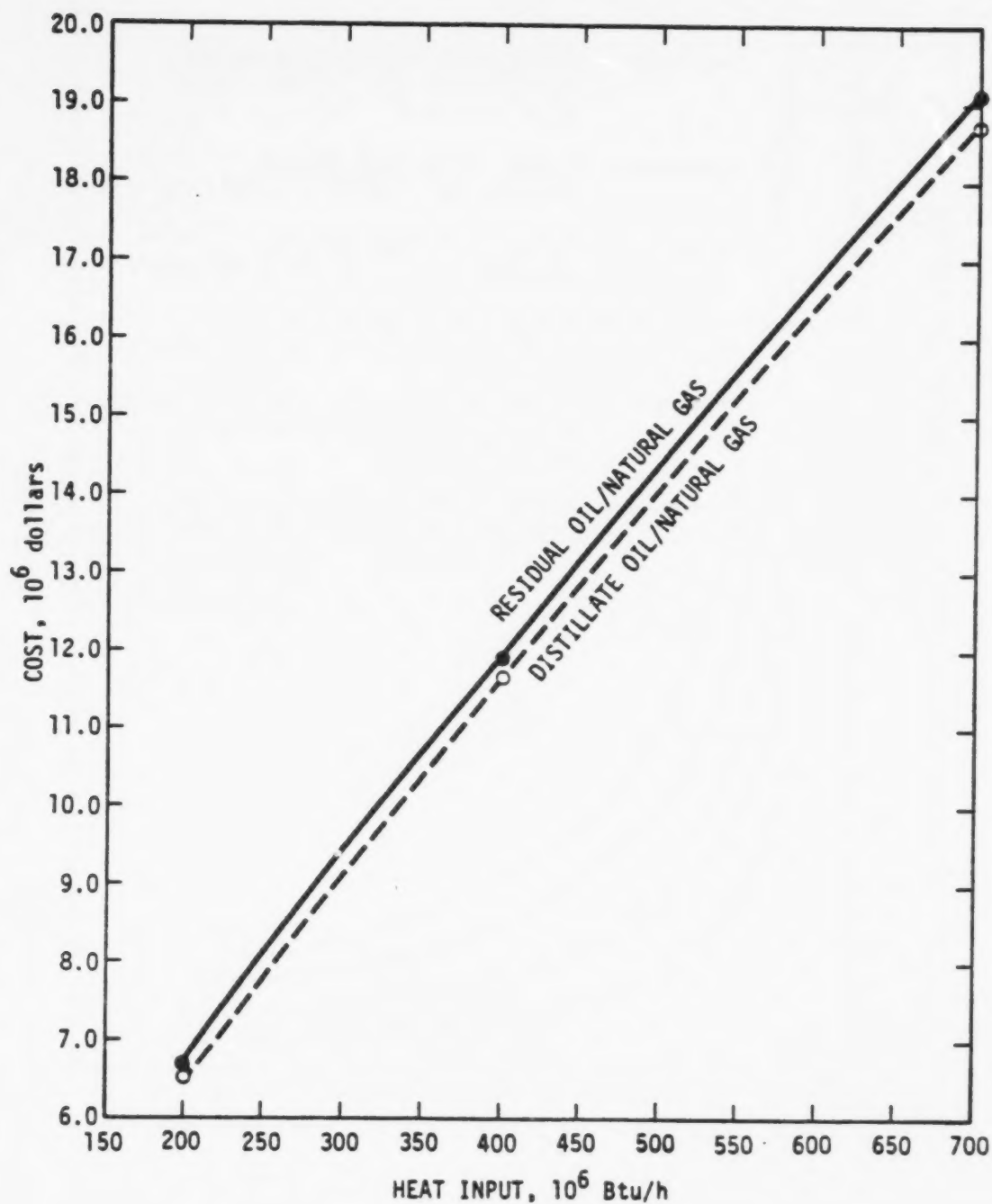


Figure 8. Total turnkey costs of dual-fuel, field-erected boilers firing residual oil/natural gas or distillate oil/natural gas versus heat input.

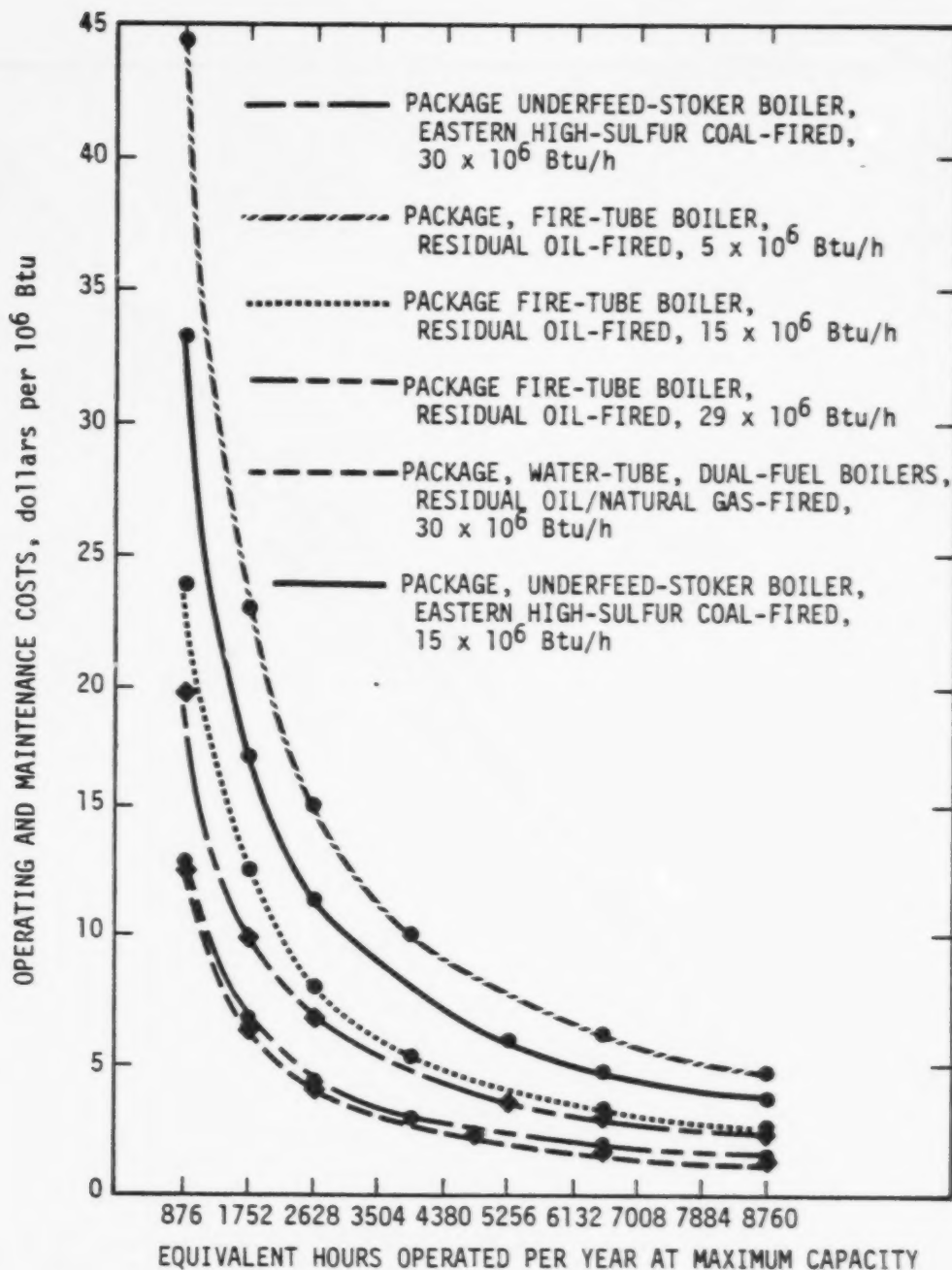


Figure 9. Operating and maintenance costs (less fuel costs) for various boilers versus equivalent hours operated per year at maximum capacity.

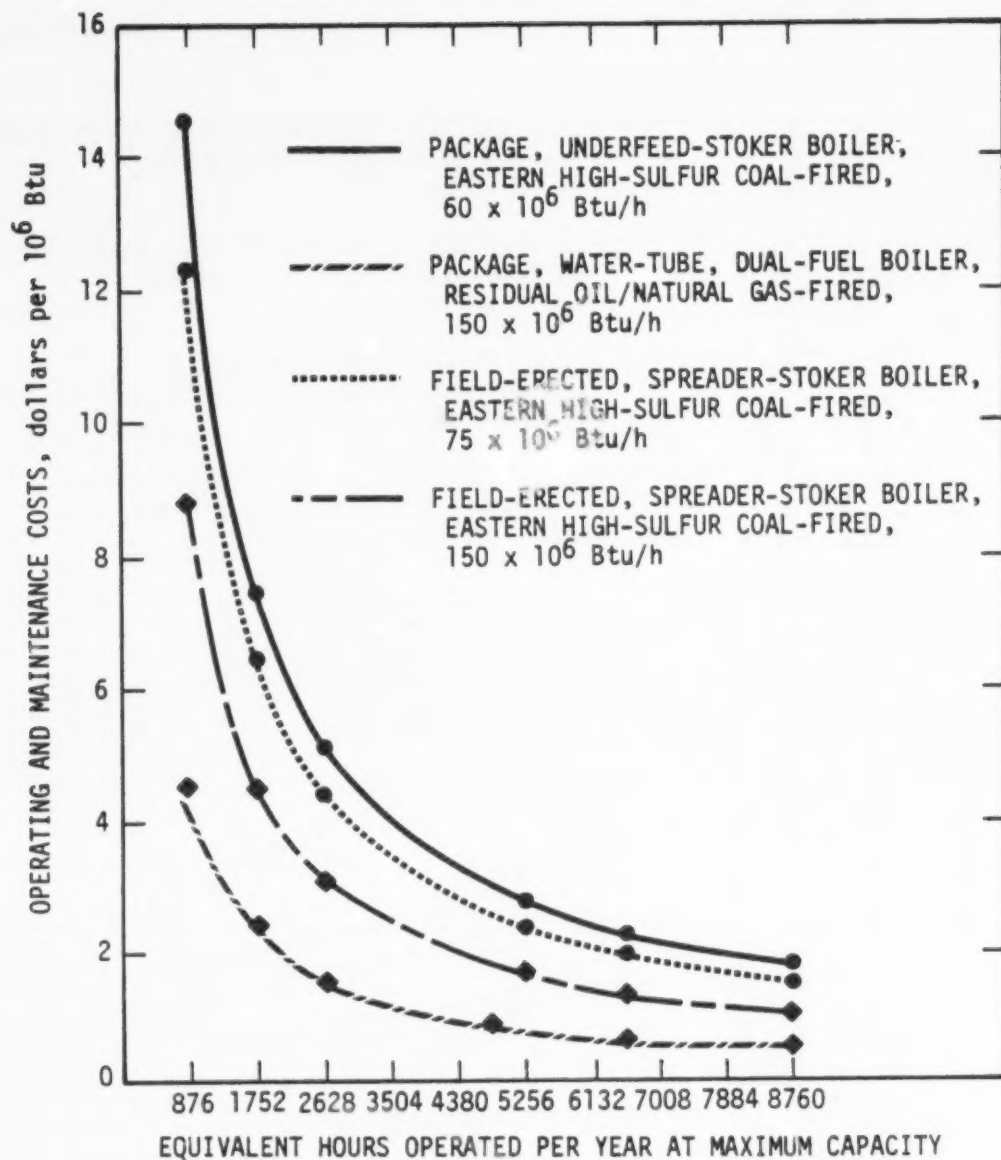


Figure 10. Operating and maintenance costs (less fuel costs) for various boilers versus equivalent hours operated per year at maximum capacity.

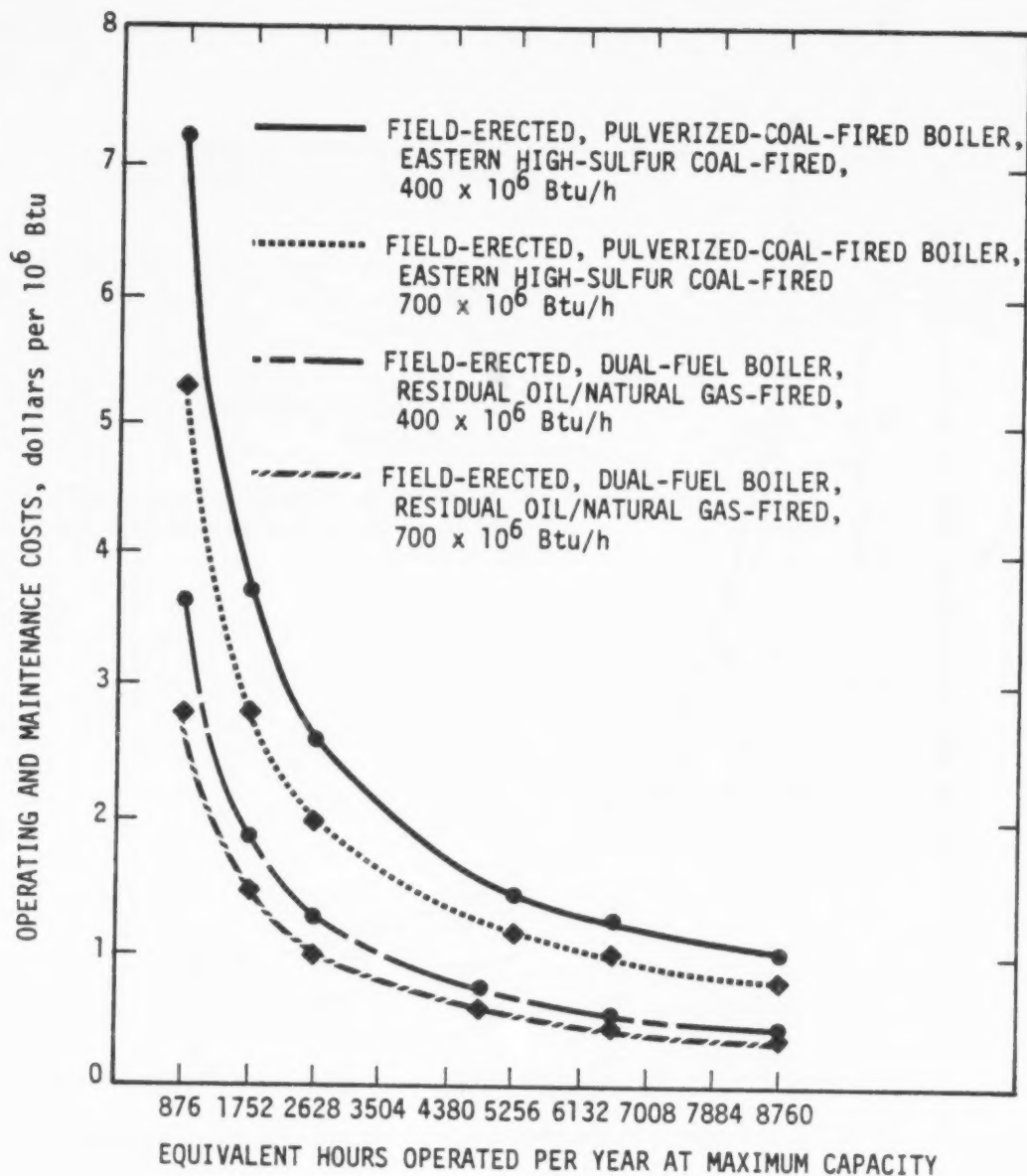


Figure 11. Operating and maintenance costs (less fuel costs) for various boilers versus equivalent hours operated per year at maximum capacity.

APPENDIX A
DETAILED CAPITAL AND ANNUALIZED COST
TABLES FOR COAL-FIRED BOILERS

TABLE A-1. ESTIMATED CAPITAL COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN HIGH-SULFUR COAL
WITH A THERMAL INPUT OF 4.4 MW
(15 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 204,800
Stack	2,700
Instrumentation	Incl. w/boiler
Stoker	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerators	Incl. w/coal handling
Heaters	N.A.
Boiler feed pumps	6,100
Condensate systems	5,000
Water treating system	5,000
Chemical feed	1,400
Compressed air system	N.A.
Coal handling system	90,100
Ash disposal system	65,500
Thawing equipment	N.A.
Fuel-oil system	N.A.
Total Equipment Cost	\$380,600

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 69,000
Stack	1,500
Instrumentation	Incl. w/boiler
Stoker	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerators	N.A.
Heaters	N.A.
Boiler feed pumps	1,200
Condensate system	1,000
Water treating system	1,500
Chemical feed	400
Coal handling system	53,800
Ash disposal system	26,900
Thawing equipment	N.A.
Fuel-oil system	N.A.

N.A. - Not applicable.

TABLE A-1. (continued)

INSTALLATION COSTS, DIRECT (cont.)	
Foundations and supports	23,400
Ductwork (not incl. w/boiler)	N.A.
Piping	23,400
Insulation	17,600
Painting	4,100
Electrical	20,000
Buildings	93,600
Total installation cost	\$ 337,400
TOTAL DIRECT COSTS (equipment + installation)	\$ 718,000
INSTALLATION COSTS, INDIRECT	
Engineering (10% of direct costs)	\$ 71,800
Construction and field expense (10% of direct costs)	71,800
Construction fees (10% of direct costs)	71,800
Start-up (2% of direct costs)	14,400
Performance tests (minimum \$2000)	3,000
TOTAL INDIRECT COSTS	\$ 232,800
Contingencies (20% of direct and indirect costs)	\$ 190,200
Total Turnkey Costs (direct+indirect+contingencies)	1,141,000
Land	2,000
Working capital (25% of total direct operating costs)	102,000
GRAND TOTAL (turnkey+land+working capital)	\$1,245,000

N.A. - Not applicable

^a Quote from Zurn Industries, Inc., May 25, 1978.

TABLE A-2. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN HIGH-SULFUR COAL
WITH A THERMAL INPUT OF 4.4 MW
(15×10^6 Btu/h; 150 psig/sat. temp. design)

DIRECT COST

Direct labor	<u>\$ 131,600</u>
Supervision	<u>68,500</u>
Maintenance labor	<u>64,100</u>
Maintenance materials	<u>a</u>
Replacement parts	<u>46,800</u>
Electricity	<u>25,800</u>
Steam	<u>N.A.</u>
Cooling water	<u>N.A.</u>
Process water	<u>200</u>
Fuel	<u>58,300</u>
Bottom ash disposal	<u>10,500</u>
Chemicals	<u>2,000</u>
Total direct cost	<u>\$ 407,800</u>

OVERHEAD

Payroll (30% of direct labor	<u>\$ 39,500</u>
Plant (26% of labor, parts & maint.)	<u>80,900</u>
Total overhead costs	<u>\$ 120,400</u>

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	<u>\$ 45,600</u>
Capital recovery factor (10.61% of total turnkey costs)	<u>121,100</u>
Interest on working capital (10% of working capital)	<u>10,200</u>
Total capital charges	<u>\$ 176,900</u>

TOTAL ANNUALIZED COSTS

\$ 705,100

a Included with replacement parts.
N.A. - Not applicable.

TABLE A-3. ESTIMATED CAPITAL COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN LOW-SULFUR COAL
WITH A THERMAL INPUT OF 4.4 MW
(15 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 175,000
Stack	2,700
Instrumentation	Incl. w/boiler
Stoker	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerators	Incl. w/condensate
Heaters	N.A.
Boiler feed pumps	6,100
Condensate systems	5,000
Water treating system	5,000
Chemical feed	1,400
Compressed air system	N.A.
Coal handling system	77,000
Ash disposal system	56,000
Thawing equipment	N.A.
Fuel-oil system	N.A.
Total Equipment Cost	\$ 328,200

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 59,000
Stack	1,500
Instrumentation	Incl. w/boiler
Stoker	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerators	N.A.
Heaters	N.A.
Boiler feed pumps	1,200
Condensate system	1,000
Water treating system	1,500
Chemical feed	400
Coal handling system	46,000
Ash disposal system	23,000
Thawing equipment	N.A.
Fuel-oil system	N.A.

N.A. - Not applicable.

TABLE A-3. (continued)

INSTALLATION COSTS, DIRECT (cont.)

Foundations and supports	20,000
Ductwork (not incl. w/boiler)	N.A.
Piping	20,000
Insulation	15,000
Painting	3,500
Electrical	20,000
Buildings	80,000
Total installation cost	<u>\$ 292,100</u>

TOTAL DIRECT COSTS (equipment + installation)	<u>\$ 620,300</u>
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INSTALLATION COSTS, INDIRECT

Engineering (10% of direct costs)	<u>\$ 62,000</u>
Construction and field expense (10% of direct costs)	<u>62,000</u>
Construction fees (10% of direct costs)	<u>62,000</u>
Start-up (2% of direct costs)	<u>12,400</u>
Performance tests (minimum \$2000)	<u>3,000</u>

TOTAL INDIRECT COSTS	<u>\$ 201,400</u>
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Contingencies (20% of direct and indirect costs)	<u>\$ 164,300</u>
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Total Turnkey Costs (direct+indirect+contingencies)	<u>986,000</u>
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Land	<u>2,000</u>
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Working capital (25% of total direct operating costs)	<u>106,600</u>
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GRAND TOTAL (turnkey+land+working capital)	<u><u>\$1,094,600</u></u>
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N.A. - Not applicable.

^aQuote from Zurn Industries, Inc., May 25, 1978.

TABLE A-4. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN LOW-SULFUR COAL
WITH A THERMAL INPUT OF 4.4 MW
(15 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

Direct labor	\$ 131,600
Supervision	68,500
Maintenance labor	64,100
Maintenance materials	a
Replacement parts	40,000
Electricity	22,000
Steam	N.A.
Cooling water	N.A.
Process water	200
Fuel	91,500
Bottom ash disposal	6,300
Chemicals	2,000
Total direct cost	\$ 426,200

OVERHEAD

Payroll (30% of direct labor)	\$ 39,500
Plant (26% of labor, parts & maint.)	79,100
Total overhead costs	\$ 118,600

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	\$ 39,400
Capital recovery factor (10.61 % of total turnkey costs)	104,600
Interest on working capital (10% of working capital)	10,700
Total capital charges	\$ 154,700

TOTAL ANNUALIZED COSTS	\$ 699,500
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a Included with replacement parts.

N.A. - Not applicable.

TABLE A-5. ESTIMATED CAPITAL COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING SUBBITUMINOUS COAL
WITH A THERMAL INPUT OF 4.4 MW
(15 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 252,000
Stack	2,700
Instrumentation	Incl. w/boiler
Stoker	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerators	Incl. w/condensate
Heaters	N.A.
Boiler feed pumps	6,100
Condensate systems	5,000
Water treating system	5,000
Chemical feed	1,400
Compressed air system	N.A.
Coal handling system	110,900
Ash disposal system	80,600
Thawing equipment	N.A.
Fuel-oil system	N.A.
Total Equipment Cost	\$ 463,700

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 85,000
Stack	1,500
Instrumentation	Incl. w/boiler
Stoker	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerators	N.A.
Heaters	N.A.
Boiler feed pumps	1,200
Condensate system	1,000
Water treating system	1,500
Chemical feed	400
Coal handling system	66,200
Ash disposal system	33,100
Thawing equipment	N.A.
Fuel-oil system	N.A.

N.A. - Not applicable.

TABLE A-5. (continued)

INSTALLATION COSTS, DIRECT (cont.)	
Foundations and supports	28,800
Ductwork (not incl. w/boiler)	N.A.
Piping	28,800
Insulation	21,600
Painting	5,000
Electrical	20,000
Buildings	115,200
Total installation cost	\$ 409,300
TOTAL DIRECT COSTS (equipment + installation)	\$ 873,000
INSTALLATION COSTS, INDIRECT	
Engineering (10% of direct costs)	\$ 87,300
Construction and field expense (10% of direct costs)	87,300
Construction fees (10% of direct costs)	87,300
Start-up (2% of direct costs)	17,500
Performance tests (minimum \$2000)	3,000
TOTAL INDIRECT COSTS	\$ 282,400
Contingencies (20% of direct and indirect costs)	\$ 231,100
Total Turnkey Costs (direct+indirect+contingencies)	1,386,500
Land	2,000
Working capital (25% of total direct operating costs)	98,800
GRAND TOTAL (turnkey+land+working capital)	\$1,487,300

N.A. - Not applicable

^aQuote from Zurn Industries, Inc., May 25, 1978.

TABLE A-6. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING SUBBITUMINOUS COAL
WITH A THERMAL INPUT OF 4.4 MW
(15 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

Direct labor	\$ 131,600
Supervision	68,500
Maintenance labor	64,100
Maintenance materials	a
Replacement parts	57,600
Electricity	31,600
Steam	N.A.
Cooling water	N.A.
Process water	200
Fuel	33,100
Bottom ash disposal	6,300
Chemicals	2,000
Total direct cost	\$ 395,000

OVERHEAD

Payroll (30% of direct labor)	\$ 39,500
Plant (26% of labor, parts & maint.)	83,700
Total overhead costs	\$ 123,200

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	\$ 55,500
Capital recovery factor (10.61 % of total turnkey costs)	147,100
Interest on working capital (10% of working capital)	9,900
Total capital charges	\$ 212,500

TOTAL ANNUALIZED COSTS \$ 730,700

a Included with replacement parts.

N.A. - Not applicable.

TABLE A-7. ESTIMATED CAPITAL COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN MEDIUM-SULFUR COAL
WITH A THERMAL INPUT OF 4.4 MW
(15 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 182,700
Stack	2,700
Instrumentation	Incl. w/boiler
Stoker	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerators	Incl. w/condensate
Heaters	N.A.
Boiler feed pumps	6,100
Condensate systems	5,000
Water treating system	5,000
Chemical feed	1,400
Compressed air system	N.A.
Coal handling system	80,400
Ash disposal system	58,500
Thawing equipment	N.A.
Fuel-oil system	N.A.
Total Equipment Cost	\$ 341,800

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 61,600
Stack	1,500
Instrumentation	Incl. w/boiler
Stoker	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerators	N.A.
Heaters	N.A.
Boiler feed pumps	1,200
Condensate system	1,000
Water treating system	1,500
Chemical feed	400
Coal handling system	48,000
Ash disposal system	24,000
Thawing equipment	N.A.
Fuel-oil system	N.A.

N.A. - Not applicable.

TABLE A-7. (continued)

INSTALLATION COSTS, DIRECT (cont.)

Foundations and supports	<u>20,900</u>
Ductwork (not incl. w/boiler)	<u>N.A.</u>
Piping	<u>20,900</u>
Insulation	<u>15,700</u>
Painting	<u>3,700</u>
Electrical	<u>20,000</u>
Buildings	<u>83,500</u>
Total installation cost	<u>\$ 303,900</u>

TOTAL DIRECT COSTS (equipment + installation)	<u>\$ 645,700</u>
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INSTALLATION COSTS, INDIRECT

Engineering (10% of direct costs)	<u>\$ 64,600</u>
Construction and field expense (10% of direct costs)	<u>64,600</u>
Construction fees (10% of direct costs)	<u>64,600</u>
Start-up (2% of direct costs)	<u>12,900</u>
Performance tests (minimum \$2000)	<u>3,000</u>

TOTAL INDIRECT COSTS	<u>\$ 209,700</u>
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Contingencies (20% of direct and indirect costs)	<u>\$ 171,100</u>
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Total Turnkey Costs (direct+indirect+contingencies)	<u>1,026,500</u>
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Land	<u>2,000</u>
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Working capital (25% of total direct operating costs)	<u>104,700</u>
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GRAND TOTAL (turnkey+land+working capital)	<u>\$1,133,200</u>
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^aQuote from Zurn Industries, Inc., May 25, 1978
N.A. - Not applicable.

TABLE A-8. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN MEDIUM-SULFUR COAL
WITH A THERMAL INPUT OF 4.4 MW
(15 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

Direct labor	\$ <u>131,600</u>
Supervision	<u>68,500</u>
Maintenance labor	<u>64,100</u>
Maintenance materials	<u>a</u>
Replacement parts	<u>41,800</u>
Electricity	<u>22,900</u>
Steam	<u>N.A.</u>
Cooling water	<u>N.A.</u>
Process water	<u>200</u>
Fuel	<u>74,900</u>
Bottom ash disposal	<u>12,600</u>
Chemicals	<u>2,000</u>
Total direct cost	\$ <u>418,600</u>

OVERHEAD

Payroll (30% of direct labor	\$ <u>39,500</u>
Plant (26% of labor, parts & maint.)	<u>79,600</u>
Total overhead costs	\$ <u>119,100</u>

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	\$ <u>41,100</u>
Capital recovery factor (10.61 % of total turnkey costs)	<u>108,900</u>
Interest on working capital (10% of working capital)	<u>10,500</u>
Total capital charges	\$ <u>160,500</u>

TOTAL ANNUALIZED COSTS	\$ <u>698,200</u>
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a Included with replacement parts.

N.A. - Not applicable.

TABLE A-9. ESTIMATED CAPITAL COSTS OF A PACKAGE,
WATER-TUBE, UNDERFEED-STOKER BOILER FIRING EASTERN HIGH-SULFUR
COAL WITH A THERMAL INPUT OF 8.8 MW
(30 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans and ducts)	\$ 308,900
Stack	3,000
Instrumentation	Incl. w/boiler
Stokers	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerator	5,200
Heaters	N.A.
Boiler feed pumps	13,400
Condensate systems	7,700
Water treating system	8,000
Chemical feed	1,400
Compressed air system	N.A.
Coal handling system	136,700
Ash disposal system	99,500
Thawing equipment	N.A.
Fuel-oil system	N.A.
Total Equipment Cost	\$ 583,800

INSTALLATION COSTS, DIRECT

Boiler (including founda- tions and steel)	\$ 105,300
Stack	1,500
Instrumentation	Incl. w/boiler
Pulverizers	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerator	2,500
Heaters	N.A.
Boiler feed pumps	3,000
Condensate system	1,100
Water treating system	2,000
Chemical feed	800
Coal handling system	81,900
Ash disposal system	41,000
Thawing equipment	N.A.
Fuel-oil system	N.A.

N.A. - Not applicable.

TABLE 'A-9. (continued)

INSTALLATION COSTS, DIRECT (cont.)	
Foundations and supports	35,100
Ductwork (not incl. w/boiler)	N.A.
Piping	41,000
Insulation	29,300
Painting	5,900
Electrical	30,000
Buildings	140,400
Total Installation Costs	\$ 520,800
TOTAL DIRECT COSTS (Equipment + Installation)	\$ 1,104,600
INSTALLATION COSTS, INDIRECT	
Engineering (10% of direct costs)	\$ 110,500
Construction and field expense (10% of direct costs)	110,500
Construction fees (10% of direct costs)	110,500
Startup (2% of direct costs)	22,100
Performance tests (minimum \$2000)	3,500
TOTAL INDIRECT COSTS	\$ 357,100
Contingencies (20% of direct and indirect costs)	\$ 292,300
Total turnkey costs (Direct + Indirect + Contingencies)	1,754,000
Land	2,000
Working capital (25% of total direct operating costs)	135,300
GRAND TOTAL (Turnkey + Land + Working Capital)	\$ 1,891,300

^a Quote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE A-10. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, WATER-TUBE
UNDERFEED-STOKER BOILER FIRING EASTERN HIGH-SULFUR
COAL WITH A THERMAL INPUT OF 8.8 MW
(30 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST	
Direct labor	\$ 157,900
Supervision	68,500
Maintenance labor	64,100
Maintenance materials	^a
Replacement parts	70,200
Electricity	40,100
Steam	N.A.
Cooling water	N.A.
Process water	500
Fuel	116,700
Bottom ash disposal	21,000
Chemicals	2,300
Total direct cost	\$ 541,300
OVERHEAD	
Payroll (30% of direct labor)	\$ 47,400
Plant (26% of labor, parts & maint.)	93,800
Total overhead costs	\$ 141,200
BYPRODUCT CREDITS	
	N.A.
CAPITAL CHARGES	
G & A, taxes & insurance (4% of total turnkey costs)	\$ 70,200
Capital recovery factor (10.61% of total turnkey costs)	186,100
Interest on working capital (10% of working capital)	13,500
Total capital charges	\$ 269,800
TOTAL ANNUALIZED COSTS	\$ 952,300

^a Included with replacement parts.

N.A. - Not applicable.

TABLE A-11. ESTIMATED CAPITAL COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN LOW-SULFUR COAL
WITH A THERMAL INPUT OF 8.8 MW
(30 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS	
DATE OF ESTIMATE	June 30, 1978 (FOR COSTS INDEXING)
EQUIPMENT COST ^a	
Boiler (with fans and duct)	\$ 264,000
Stack	3,000
Instrumentation	Incl. w/boiler
Stokers	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerator	5,200
Heaters	N.A.
Boiler feed pumps	13,400
Condensate systems	7,700
Water treating system	8,000
Chemical feed	1,400
Compressed air system	N.A.
Coal handling system	116,800
Ash disposal system	85,000
Thawing equipment	N.A.
Fuel-oil system	N.A.
Total Equipment Cost	\$ 504,500
INSTALLATION COSTS, DIRECT	
Boiler (including foundations and steel)	\$ 90,000
Stack	1,500
Instrumentation	Incl. w/boiler
Pulverizers	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerator	2,500
Heaters	N.A.
Boiler feed pumps	3,000
Condensate system	1,100
Water treating system	2,000
Chemical feed	800
Coal handling system	70,000
Ash disposal system	35,000
Thawing equipment	N.A.
Fuel-oil system	N.A.

N.A. - Not applicable.

TABLE A-11.(continued)

INSTALLATION COSTS, DIRECT (cont.)	
Foundations and supports	30,000
Ductwork (not incl. w/boiler)	N.A.
Piping	35,000
Insulation	25,000
Painting	5,000
Electrical	30,000
Buildings	120,000
Total Installation Costs	\$ 450,900
TOTAL DIRECT COSTS (Equipment + Installation)	\$ 955,400
INSTALLATION COSTS, INDIRECT	
Engineering (10% of direct costs)	\$ 95,500
Construction and field expense (10% of direct costs)	95,500
Construction fees (10% of direct costs)	95,500
Startup (2% of direct costs)	19,100
Performance tests (minimum \$2000)	3,500
TOTAL INDIRECT COSTS	\$ 309,100
Contingencies (20% of direct and indirect costs)	\$ 252,900
Total turnkey costs (Direct + Indirect + Contingencies)	1,517,400
Land	2,000
Working capital (25% of total direct operating costs)	145,800
GRAND TOTAL (Turnkey + Land + Working Capital)	\$ 1,665,200

^a Quote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE A-12. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN LOW-SULFUR
COAL WITH A THERMAL INPUT OF 8.8 MW
(30 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

Direct labor	\$ 157,900
Supervision	68,500
Maintenance labor	64,100
Maintenance materials	a
Replacement parts	60,000
Electricity	34,300
Steam	N.A.
Cooling water	N.A.
Process water	500
Fuel	182,900
Bottom ash disposal	12,600
Chemicals	2,300
Total direct cost	\$ 583,100

OVERHEAD

Payroll (30% of direct labor)	\$ 47,400
Plant (26% of labor, parts & maint.)	91,100
Total overhead costs	\$ 138,500

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	\$ 60,700
Capital recovery factor (10.61% of total turnkey costs)	161,000
Interest on working capital (10% of working capital)	14,600
Total capital charges	\$ 236,300

TOTAL ANNUALIZED COSTS

\$ 957,900

^a Included with replacement parts.

N.A. - Not applicable.

TABLE A-13. ESTIMATED CAPITAL COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING SUBBITUMINOUS COAL
WITH A THERMAL INPUT OF 8.8 MW
(30 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COSTS

Boiler (with fans and ducts)	\$ 380,200
Stack	3,000
Instrumentation	Incl. w/boiler
Stokers	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerator	5,200
Heaters	N.A.
Boiler feed pumps	13,400
Condensate systems	7,700
Water treating system	8,000
Chemical feed	1,400
Compressed air system	N.A.
Coal handling system	168,200
Ash disposal system	122,400
Thawing equipment	N.A.
Fuel-oil system	N.A.

Total Equipment Cost \$ 709,500

INSTALLATION COSTS, DIRECT

Boiler (including foundations and steel)	\$ 129,600
Stack	1,500
Instrumentation	Incl. w/boiler
Stokers	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerator	2,500
Heaters	N.A.
Boiler feed pumps	3,000
Condensate system	1,100
Water treating system	2,000
Chemical feed	800
Coal handling system	100,800
Ash disposal system	50,400
Thawing equipment	N.A.
Fuel-oil system	N.A.

N.A. - Not applicable.

TABLE A-13. (continued)

INSTALLATION COSTS, DIRECT (cont.)

Foundations and supports	43,200
Ductwork (not incl. w/boiler)	N.A.
Piping	50,400
Insulation	36,000
Painting	7,200
Electrical	30,000
Buildings	172,800

Total Installation Costs	\$ 631,300
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TOTAL DIRECT COSTS

(Equipment + Installation)	\$ 1,340,800
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INSTALLATION COSTS, INDIRECT

Engineering (10% of direct costs)	\$ 134,100
Construction and field expense (10% of direct costs)	134,100
Construction fees (10% of direct costs)	134,100
Startup (2% of direct costs)	26,800
Performance tests (minimum \$2000)	3,500

TOTAL INDIRECT COSTS	\$ 432,600
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Contingencies (20% of direct and indirect costs)	\$ 354,700
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Total turnkey costs (Direct + Indirect + Contingencies)	2,128,100
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Land	2,000
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Working capital (25% of total direct operating costs)	127,000
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GRAND TOTAL (Turnkey + Land + Working Capital)	\$ 2,257,100
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^a Quote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE A-14. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING SUBBITUMINOUS
COAL WITH A THERMAL INPUT OF 8.8 MW
(30×10^6 Btu/h; 150 psig/sat. temp. design)

DIRECT COST	
Direct labor	\$ 157,900
Supervision	68,500
Maintenance labor	64,100
Maintenance materials	a
Replacement parts	86,400
Electricity	49,400
Steam	N.A.
Cooling water	N.A.
Process water	500
Fuel	66,200
Bottom ash disposal	12,600
Chemicals	2,300
Total direct cost	\$ 507,900
OVERHEAD	
Payroll (30% of direct labor)	\$ 47,400
Plant (26% of labor, parts & maint.)	98,000
Total overhead costs	\$ 145,400
BYPRODUCT CREDITS	N.A.
CAPITAL CHARGES	
G & A, taxes & insurance (4% of total turnkey costs)	\$ 85,100
Capital recovery factor (10.61% of total turnkey costs)	225,800
Interest on working capital (10% of working capital)	12,700
Total capital charges	\$ 323,600
TOTAL ANNUALIZED COSTS	\$ 976,900

^a Included with replacement parts.

N.A. - Not applicable.

TABLE A-15. ESTIMATED CAPITAL COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN MEDIUM-SULFUR COAL
WITH A THERMAL INPUT OF 8.8 MW
(30 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST

Boiler (with fans & ducts)	\$ <u>276,000</u>
Stack	<u>3,000</u>
Instrumentation	<u>Incl. w/boiler</u>
Stoker	<u>Incl. w/boiler</u>
Feeders	<u>Incl. w/coal handling</u>
Crushers	<u>Incl. w/coal handling</u>
Deaerators	<u>5,200</u>
Heaters	<u>N.A.</u>
Boiler feed pumps	<u>13,400</u>
Condensate systems	<u>7,700</u>
Water treating system	<u>8,000</u>
Chemical feed	<u>1,400</u>
Compressed air system	<u>N.A.</u>
Coal handling system	<u>122,000</u>
Ash disposal system	<u>89,000</u>
Thawing equipment	<u>N.A.</u>
Fuel-oil system	<u>N.A.</u>
Total Equipment Cost	\$ <u>525,700</u>

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ <u>94,000</u>
Stack	<u>1,500</u>
Instrumentation	<u>Incl. w/boiler</u>
Stoker	<u>Incl. w/boiler</u>
Feeders	<u>Incl. w/coal handling</u>
Crushers	<u>Incl. w/coal handling</u>
Deaerators	<u>2,500</u>
Heaters	<u>N.A.</u>
Boiler feed pumps	<u>3,000</u>
Condensate system	<u>1,100</u>
Water treating system	<u>2,000</u>
Chemical feed	<u>800</u>
Coal handling system	<u>73,000</u>
Ash disposal system	<u>37,000</u>
Thawing equipment	<u>N.A.</u>
Fuel-oil system	<u>N.A.</u>

N.A. - Not applicable.

TABLE A-15. (continued)

INSTALLATION COSTS, DIRECT (cont.)	
Foundations and supports	31,000
Ductwork (not incl. w/boiler)	N.A.
Piping	37,000
Insulation	26,000
Painting	5,000
Electrical	30,000
Buildings	125,000
Total installation cost	\$ 468,900
TOTAL DIRECT COSTS (equipment + installation)	\$ 994,600
INSTALLATION COSTS, INDIRECT	
Engineering (10% of direct costs)	\$ 99,500
Construction and field expense (10% of direct costs)	99,500
Construction fees (10% of direct costs)	99,500
Start-up (2% of direct costs)	19,900
Performance tests (minimum \$2000)	3,500
TOTAL INDIRECT COSTS	\$ 321,900
Contingencies (20% of direct and indirect costs)	\$ 263,300
Total Turnkey Costs (direct+indirect+contingencies)	1,579,800
Land	2,000
Working capital (25% of total direct operating costs)	141,200
GRAND TOTAL (turnkey+land+working capital)	\$1,723,000

N.A. - Not applicable.

TABLE A-16. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN MEDIUM-SULFUR COAL
WITH A THERMAL INPUT OF 8.8 MW
(30 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST	
Direct labor	\$ 157,900
Supervision	68,500
Maintenance labor	64,100
Maintenance materials	a
Replacement parts	62,600
Electricity	35,800
Steam	N.A.
Cooling water	N.A.
Process water	500
Fuel	149,800
Bottom ash disposal	23,100
Chemicals	2,300
Total direct cost	\$ 564,600
OVERHEAD	
Payroll (30% of direct labor	\$ 47,400
Plant (26% of labor, parts & maint.)	91,800
Total overhead costs	\$ 139,200
BY-PRODUCT CREDITS	N.A.
CAPITAL CHARGES	
G & A, taxes & insurance (4% of total turnkey costs)	\$ 63,200
Capital recovery factor (10.61% of total turnkey costs)	167,600
Interest on working capital (10% of working capital)	14,100
Total capital charges	\$ 244,900
TOTAL ANNUALIZED COSTS	\$ 948,700
a Included with replacement parts.	
N.A. - Not applicable.	

TABLE A-17. ESTIMATED CAPITAL COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN HIGH-SULFUR COAL
WITH A THERMAL INPUT OF 17.6 MW
(60 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 579,200
Stack	9,500
Instrumentation	Incl. w/boiler
Stoker	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerators	13,500
Heaters	N.A.
Boiler feed pumps	18,000
Condensate systems	8,000
Water treating system	12,500
Chemical feed	1,400
Compressed air system	N.A.
Coal handling system	146,300
Ash disposal system	128,700
Thawing equipment	N.A.
Fuel-oil system	N.A.
Total Equipment Cost	\$ 917,100

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 193,100
Stack	4,700
Instrumentation	Incl. w/boiler
Stoker	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerators	3,000
Heaters	N.A.
Boiler feed pumps	4,800
Condensate system	1,100
Water treating system	2,100
Chemical feed	1,500
Coal handling system	146,300
Ash disposal system	58,500
Thawing equipment	N.A.
Fuel-oil system	N.A.

N.A. - Not applicable.

TABLE A-17. (continued)

INSTALLATION COSTS, DIRECT (cont.)

Foundations and supports	<u>70,200</u>
Ductwork (not incl. w/boiler)	<u>N.A.</u>
Piping	<u>52,700</u>
Insulation	<u>41,000</u>
Painting	<u>7,500</u>
Electrical	<u>60,000</u>
Buildings	<u>198,900</u>

Total installation cost \$ 845,400

TOTAL DIRECT COSTS
(equipment + installation) \$1,762,500

INSTALLATION COSTS, INDIRECT

Engineering (10% of direct costs)	<u>\$ 176,300</u>
Construction and field expense (10% of direct costs)	<u>176,300</u>
Construction fees (10% of direct costs)	<u>176,300</u>
Start-up (2% of direct costs)	<u>35,300</u>
Performance tests (minimum \$2000)	<u>6,000</u>

TOTAL INDIRECT COSTS \$ 570,200

Contingencies
(20% of direct and indirect costs) \$ 466,500

Total Turnkey Costs
(direct+indirect+contingencies) 2,799,200

Land 2,000

Working capital (25% of total direct
operating costs) 220,600

GRAND TOTAL
(turnkey+land+working capital) \$3,021,800

^aQuote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE A-18. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN HIGH-SULFUR COAL
WITH A THERMAL INPUT OF 17.6 MW
(60 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

Direct labor	\$ 184,300
Supervision	136,900
Maintenance labor	128,200
Maintenance materials	a
Replacement parts	99,500
Electricity	53,200
Steam	N.A.
Cooling water	N.A.
Process water	900
Fuel	233,400
Bottom ash disposal	42,000
Chemicals	4,000
Total direct cost	\$ 882,400

OVERHEAD

Payroll (30% of direct labor	\$ 55,300
Plant (26% of labor, parts & maint.)	142,700
Total overhead costs	\$ 198,000

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	\$ 112,000
Capital recovery factor (10.61 % of total turnkey costs)	297,000
Interest on working capital (10% of working capital)	22,100
Total capital charges	\$ 431,100

TOTAL ANNUALIZED COSTS \$ 1,511,500

a Included with replacement parts.

N.A. - Not applicable.

TABLE A-19. ESTIMATED CAPITAL COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN LOW-SULFUR COAL
WITH A THERMAL INPUT OF 17.6 MW
(60 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ <u>495,000</u>
Stack	<u>9,500</u>
Instrumentation	<u>Incl. w/boiler</u>
Stoker	<u>Incl. w/boiler</u>
Feeders	<u>Incl. w/coal handling</u>
Crushers	<u>Incl. w/coal handling</u>
Deaerators	<u>13,500</u>
Heaters	<u>N.A.</u>
Boiler feed pumps	<u>18,000</u>
Condensate systems	<u>8,000</u>
Water treating system	<u>12,500</u>
Chemical feed	<u>1,400</u>
Compressed air system	<u>N.A.</u>
Coal handling system	<u>125,000</u>
Ash disposal system	<u>110,000</u>
Thawing equipment	<u>N.A.</u>
Fuel-oil system	<u>N.A.</u>
Total Equipment Cost	\$ <u>792,900</u>

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ <u>165,000</u>
Stack	<u>4,700</u>
Instrumentation	<u>Incl. w/boiler</u>
Stoker	<u>Incl. w/boiler</u>
Feeders	<u>Incl. w/coal handling</u>
Crushers	<u>Incl. w/coal handling</u>
Deaerators	<u>3,000</u>
Heaters	<u>N.A.</u>
Boiler feed pumps	<u>4,800</u>
Condensate system	<u>1,100</u>
Water treating system	<u>2,100</u>
Chemical feed	<u>1,500</u>
Coal handling system	<u>125,000</u>
Ash disposal system	<u>50,000</u>
Thawing equipment	<u>N.A.</u>
Fuel-oil system	<u>N.A.</u>

N.A. - Not applicable.

TABLE A-19. (continued)

INSTALLATION COSTS, DIRECT (cont.)

Foundations and supports	60,000
Ductwork (not incl. w/boiler)	N.A.
Piping	45,000
Insulation	35,000
Painting	6,400
Electrical	60,000
Buildings	170,000

Total installation cost	\$ 733,600
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TOTAL DIRECT COSTS

(equipment + installation)	\$1,526,500
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INSTALLATION COSTS, INDIRECT

Engineering	
(10% of direct costs)	\$ 152,700
Construction and field expense	
(10% of direct costs)	152,700
Construction fees	
(10% of direct costs)	152,700
Start-up (2% of direct costs)	30,500
Performance tests (minimum \$2000)	6,000

TOTAL INDIRECT COSTS	\$ 494,600
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Contingencies

(20% of direct and indirect costs)	\$ 404,200
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Total Turnkey Costs

(direct+indirect+contingencies)	2,425,300
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Land

2,000

Working capital (25% of total direct operating costs)	243,400
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GRAND TOTAL

(turnkey+land+working capital)	\$2,670,700
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^aQuote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE A-20. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN LOW-SULFUR COAL
WITH A THERMAL INPUT OF 17.6 MW
(60 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

Direct labor	\$ 184,300
Supervision	136,900
Maintenance labor	128,200
Maintenance materials	a
Replacement parts	85,000
Electricity	45,400
Steam	N.A.
Cooling water	N.A.
Process water	900
Fuel	365,800
Bottom ash disposal	23,100
Chemicals	4,000
Total direct cost	\$ 973,600

OVERHEAD

Payroll (30% of direct labor	\$ 55,300
Plant (26% of labor, parts & maint.)	138,900
Total overhead costs	\$ 194,200

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	\$ 97,000
Capital recovery factor (10.61% of total turnkey costs)	257,300
Interest on working capital (10% of working capital)	24,300
Total capital charges	\$ 378,600

TOTAL ANNUALIZED COSTS \$1,546,400

a Included with replacement parts.

N.A. - Not applicable.

TABLE A-21. ESTIMATED CAPITAL COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING SUBBITUMINOUS COAL
WITH A THERMAL INPUT OF 17.6 MW
(60 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 712,800
Stack	9,500
Instrumentation	Incl. w/boiler
Stoker	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerators	13,500
Heaters	N.A.
Boiler feed pumps	18,000
Condensate systems	8,000
Water treating system	12,500
Chemical feed	1,400
Compressed air system	N.A.
Coal handling system	180,000
Ash disposal system	158,400
Thawing equipment	N.A.
Fuel-oil system	N.A.
Total Equipment Cost	\$1,114,100

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 237,600
Stack	4,700
Instrumentation	Incl. w/boiler
Stoker	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerators	3,000
Heaters	N.A.
Boiler feed pumps	4,800
Condensate system	1,100
Water treating system	2,100
Chemical feed	1,500
Coal handling system	180,000
Ash disposal system	72,000
Thawing equipment	N.A.
Fuel-oil system	N.A.

N.A. - Not applicable.

TABLE A-21. (continued)

INSTALLATION COSTS, DIRECT (cont.)

Foundations and supports	<u>86,400</u>
Ductwork (not incl. w/boiler)	<u>N.A.</u>
Piping	<u>64,800</u>
Insulation	<u>50,400</u>
Painting	<u>9,200</u>
Electrical	<u>60,000</u>
Buildings	<u>244,800</u>

Total installation cost	<u>\$1,022,400</u>
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TOTAL DIRECT COSTS

(equipment + installation)	<u>\$2,136,500</u>
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INSTALLATION COSTS, INDIRECT

Engineering (10% of direct costs)	<u>\$ 213,700</u>
Construction and field expense (10% of direct costs)	<u>213,700</u>
Construction fees (10% of direct costs)	<u>213,700</u>
Start-up (2% of direct costs)	<u>42,700</u>
Performance tests (minimum \$2000)	<u>6,000</u>

TOTAL INDIRECT COSTS	<u>\$ 689,800</u>
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Contingencies

(20% of direct and indirect costs)	<u>\$ 565,300</u>
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Total Turnkey Costs

(direct+indirect+contingencies)	<u>3,391,600</u>
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Land

<u>2,000</u>

Working capital (25% of total direct operating costs)	<u>200,500</u>
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GRAND TOTAL

(turnkey+land+working capital)	<u>\$3,594,100</u>
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^aQuote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE A-22. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING SUBBITUMINOUS COAL
WITH A THERMAL INPUT OF 17.6 MW
(60 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

Direct labor	\$ 184,300
Supervision	136,900
Maintenance labor	128,200
Maintenance materials	a
Replacement parts	122,400
Electricity	65,400
Steam	N.A.
Cooling water	N.A.
Process water	900
Fuel	132,500
Bottom ash disposal	27,300
Chemicals	4,000
Total direct cost	\$ 801,900

OVERHEAD

Payroll (30% of direct labor	\$ 55,300
Plant (26% of labor, parts & maint.)	148,700
Total overhead costs	\$ 204,000

BY-PRODUCT CREDITS	N.A.
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CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	\$ 135,700
Capital recovery factor (10.61 % of total turnkey costs)	359,800
Interest on working capital (10% of working capital)	20,100
Total capital charges	\$ 515,600

TOTAL ANNUALIZED COSTS	\$ 1,521,500
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a Included with replacement parts.

N.A. - Not applicable.

TABLE A-23. ESTIMATED CAPITAL COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN MEDIUM-SULFUR COAL
WITH A THERMAL INPUT OF 17.6 MW
(60 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ <u>516,800</u>
Stack	<u>9,500</u>
Instrumentation	<u>Incl. w/boiler</u>
Stoker	<u>Incl. w/boiler</u>
Feeders	<u>Incl. w/coal handling</u>
Crushers	<u>Incl. w/coal handling</u>
Deaerators	<u>13,500</u>
Heaters	<u>N.A.</u>
Boiler feed pumps	<u>18,000</u>
Condensate systems	<u>8,000</u>
Water treating system	<u>12,500</u>
Chemical feed	<u>1,400</u>
Compressed air system	<u>N.A.</u>
Coal handling system	<u>130,500</u>
Ash disposal system	<u>114,800</u>
Thawing equipment	<u>N.A.</u>
Fuel-oil system	<u>N.A.</u>
Total Equipment Cost	\$ <u>825,000</u>

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ <u>172,300</u>
Stack	<u>4,700</u>
Instrumentation	<u>Incl. w/boiler</u>
Stoker	<u>Incl. w/boiler</u>
Feeders	<u>Incl. w/coal handling</u>
Crushers	<u>Incl. w/coal handling</u>
Deaerators	<u>3,000</u>
Heaters	<u>N.A.</u>
Boiler feed pumps	<u>4,800</u>
Condensate system	<u>1,100</u>
Water treating system	<u>2,100</u>
Chemical feed	<u>1,500</u>
Coal handling system	<u>130,500</u>
Ash disposal system	<u>52,200</u>
Thawing equipment	<u>N.A.</u>
Fuel-oil system	<u>N.A.</u>

N.A. - Not applicable.

TABLE A-23. (continued)

INSTALLATION COSTS, DIRECT (cont.)

Foundations and supports	<u>62,600</u>
Ductwork (not incl. w/boiler)	<u>N.A.</u>
Piping	<u>47,000</u>
Insulation	<u>36,500</u>
Painting	<u>6,700</u>
Electrical	<u>60,000</u>
Buildings	<u>177,500</u>

Total installation cost	\$ <u>762,500</u>
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TOTAL DIRECT COSTS (equipment + installation)	\$ <u>1,587,500</u>
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INSTALLATION COSTS, INDIRECT

Engineering (10% of direct costs)	\$ <u>158,800</u>
Construction and field expense (10% of direct costs)	<u>158,800</u>
Construction fees (10% of direct costs)	<u>158,800</u>
Start-up (2% of direct costs)	<u>31,800</u>
Performance tests (minimum \$2000)	<u>6,000</u>

TOTAL INDIRECT COSTS	\$ <u>514,200</u>
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Contingencies (20% of direct and indirect costs)	\$ <u>420,300</u>
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Total Turnkey Costs (direct+indirect+contingencies)	<u>2,522,000</u>
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Land	<u>2,000</u>
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Working capital (25% of total direct operating costs)	<u>234,100</u>
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GRAND TOTAL (turnkey+land+working capital)	\$ <u>2,758,100</u>
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^aQuote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE A-24. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN MEDIUM-SULFUR COAL
WITH A THERMAL INPUT OF 17.6 MW
(60 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

Direct labor	\$ <u>184,300</u>
Supervision	<u>136,900</u>
Maintenance labor	<u>128,200</u>
Maintenance materials	<u>a</u>
Replacement parts	<u>88,700</u>
Electricity	<u>47,500</u>
Steam	<u>N.A.</u>
Cooling water	<u>N.A.</u>
Process water	<u>900</u>
Fuel	<u>299,600</u>
Bottom ash disposal	<u>46,300</u>
Chemicals	<u>4,000</u>
Total direct cost	\$ <u>936,400</u>

OVERHEAD

Payroll (30% of direct labor	\$ <u>55,300</u>
Plant (26% of labor, parts & maint.)	<u>139,900</u>
Total overhead costs	\$ <u>195,200</u>

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	\$ <u>100,900</u>
Capital recovery factor (10.61 % of total turnkey costs)	<u>267,600</u>
Interest on working capital (10% of working capital)	<u>23,400</u>
Total capital charges	\$ <u>391,900</u>

TOTAL ANNUALIZED COSTS \$1,523,500

a Included with replacement parts.
N.A. - Not applicable.

TABLE A-25. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED, WATER-TUBE
SPREADER-STOKER BOILER FIRING EASTERN HIGH-SULFUR
COAL WITH A THERMAL INPUT OF 22 MW
(75 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 760,500
Stack	80,000
Instrumentation	50,000
Stoker	175,500
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerators	15,900
Heaters	N.A.
Boiler feed pumps	25,300
Condensate systems	8,700
Water treating system	15,000
Chemical feed	1,400
Compressed air system	N.A.
Coal handling system	165,400
Ash disposal system	136,000
Thawing equipment	N.A.
Fuel-oil system	N.A.
Total Equipment Cost	\$ 1,433,700

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 491,400
Stack	20,000
Instrumentation	15,000
Stoker	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerators	3,500
Heaters	N.A.
Boiler feed pumps	5,500
Condensate system	1,300
Water treating system	2,500
Chemical feed	1,500
Coal handling system	175,500
Ash disposal system	70,200
Thawing equipment	N.A.
Fuel-oil system	N.A.

N.A. - Not applicable.

TABLE A-25. (continued)

INSTALLATION COSTS, DIRECT (cont.)

Foundations and supports	93,600
Ductwork (not incl. w/boiler)	N.A.
Piping	58,500
Insulation	46,800
Painting	8,200
Electrical	75,000
Buildings	234,000

Total installation cost	\$1,302,500
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TOTAL DIRECT COSTS

(equipment + installation)	\$2,736,200
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INSTALLATION COSTS, INDIRECT

Engineering (10% of direct costs)	\$ 273,600
Construction and field expense (10% of direct costs)	273,600
Construction fees (10% of direct costs)	273,600
Start-up (2% of direct costs)	54,700
Performance tests (minimum \$2000)	7,000

TOTAL INDIRECT COSTS	\$ 882,500
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Contingencies (20% of direct and indirect costs)	\$ 723,700
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Total Turnkey Costs (direct+indirect+contingencies)	4,342,400
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Land	2,000
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Working capital (25% of total direct operating costs)	243,300
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GRAND TOTAL (turnkey+land+working capital)	\$4,587,700
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^aQuote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE A-26. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN HIGH-SULFUR COAL

WITH A THERMAL INPUT OF 22 MW
(75 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

Direct labor	\$ 210,600
Supervision	136,900
Maintenance labor	128,200
Maintenance materials	a
Replacement parts	117,000
Electricity	57,600
Steam	N.A.
Cooling water	N.A.
Process water	1,100
Fuel	291,700
Bottom ash disposal	25,200
Chemicals	4,900
Total direct cost	\$ 973,200

OVERHEAD

Payroll (30% of direct labor	\$ 63,200
Plant (26% of labor, parts & maint.)	154,100
Total overhead costs	\$ 217,300

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	\$ 173,700
Capital recovery factor (10.14 % of total turnkey costs)	440,300
Interest on working capital (10% of working capital)	24,300
Total capital charges	\$ 638,300

TOTAL ANNUALIZED COSTS \$1,828,800

a Included with replacement parts.

N.A. - Not applicable.

TABLE A-27. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN LOW-SULFUR COAL WITH A THERMAL INPUT OF 22 MW (75 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 650,000
Stack	80,000
Instrumentation	50,000
Stoker	150,000
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerators	15,900
Heaters	N.A.
Boiler feed pumps	25,300
Condensate systems	8,700
Water treating system	15,000
Chemical feed	1,400
Compressed air system	N.A.
Coal handling system	141,400
Ash disposal system	116,200
Thawing equipment	N.A.
Fuel-oil system	N.A.
Total Equipment Cost	\$ 1,253,900

INSTALLATION COST, DIRECT

Boiler (including foundations and steel)	\$ 420,000
Stack	20,000
Instrumentation	15,000
Stoker	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerators	3,500
Heaters	N.A.
Boiler feed pumps	5,500
Condensate system	1,300
Water treating system	2,500
Chemical feed	1,500
Coal handling system	150,000
Ash disposal system	60,000
Thawing equipment	N.A.
Fuel-oil system	N.A.

N.A. - Not applicable.

TABLE A-27. (continued)

INSTALLATION COSTS, DIRECT (cont.)

Foundations and supports	80,000
Ductwork (not incl. w/boiler)	N.A.
Piping	50,000
Insulation	40,000
Painting	7,000
Electrical	75,000
Buildings	200,000

Total installation cost	\$1,131,300
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TOTAL DIRECT COSTS (equipment + installation)	\$2,385,200
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INSTALLATION COSTS, INDIRECT

Engineering (10% of direct costs)	\$ 238,500
Construction and field expense (10% of direct costs)	238,500
Construction fees (10% of direct costs)	238,500
Start-up (2% of direct costs)	47,700
Performance tests (minimum \$2000)	7,000

TOTAL INDIRECT COSTS	\$ 770,200
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Contingencies (20% of direct and indirect costs)	\$ 631,100
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Total Turnkey Costs (direct+indirect+contingencies)	3,786,500
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Land	2,000
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Working capital (25% of total direct operating costs)	275,700
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GRAND TOTAL (turnkey+land+working capital)	\$4,064,200
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^a Quote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE A-28. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN LOW-SULFUR COAL COAL WITH A THERMAL INPUT OF 22 MW (75 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

Direct labor	\$ 210,600
Supervision	<u>136,900</u>
Maintenance labor	<u>128,200</u>
Maintenance materials	<u>a</u>
Replacement parts	<u>100,000</u>
Electricity	<u>49,200</u>
Steam	<u>N.A.</u>
Cooling water	<u>N.A.</u>
Process water	<u>1,100</u>
Fuel	<u>457,300</u>
Bottom ash disposal	<u>14,700</u>
Chemicals	<u>4,900</u>
Total direct cost	<u>\$1,102,900</u>

OVERHEAD

Payroll (30% of direct labor	\$ <u>63,200</u>
Plant (26% of labor, parts & maint.)	<u>149,700</u>
Total overhead costs	<u>\$ 212,900</u>

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	\$ <u>151,500</u>
Capital recovery factor (10.14 % of total turnkey costs)	<u>384,000</u>
Interest on working capital (10% of working capital)	<u>27,600</u>
Total capital charges	<u>\$ 563,100</u>

TOTAL ANNUALIZED COSTS \$1,878,900 ✓

a Included with replacement parts.

N.A. - Not applicable.

TABLE A-29. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING SUBBITUMINOUS COAL WITH A THERMAL INPUT OF 22 MW (75 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 936,000
Stack	80,000
Instrumentation	50,000
Stoker	216,000
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerators	15,900
Heaters	N.A.
Boiler feed pumps	25,300
Condensate systems	8,700
Water treating system	15,000
Chemical feed	1,400
Compressed air system	N.A.
Coal handling system	203,600
Ash disposal system	167,300
Thawing equipment	N.A.
Fuel-oil system	N.A.
Total Equipment Cost	\$ 1,719,200

INSTALLATION COST, DIRECT

Boiler (including foundations and steel)	\$ 601,000
Stack	20,000
Instrumentation	15,000
Stoker	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerators	3,500
Heaters	N.A.
Boiler feed pumps	5,500
Condensate system	1,300
Water treating system	2,500
Chemical feed	1,500
Coal handling system	216,000
Ash disposal system	86,400
Thawing equipment	N.A.
Fuel-oil system	N.A.

N.A. - Not applicable.

TABLE A-29. (continued)

INSTALLATION COSTS, DIRECT (cont.)	
Foundations and supports	<u>115,200</u>
Ductwork (not incl. w/boiler)	<u>N.A.</u>
Piping	<u>72,000</u>
Insulation	<u>57,600</u>
Painting	<u>10,100</u>
Electrical	<u>75,000</u>
Buildings	<u>288,000</u>
Total installation cost	\$ <u>1,570,600</u>
TOTAL DIRECT COSTS (equipment + installation)	\$ <u>3,289,800</u>
INSTALLATION COSTS, INDIRECT	
Engineering (10% of direct costs)	\$ <u>329,000</u>
Construction and field expense (10% of direct costs)	<u>329,000</u>
Construction fees (10% of direct costs)	<u>329,000</u>
Start-up (2% of direct costs)	<u>65,800</u>
Performance tests (minimum \$2000)	<u>7,000</u>
TOTAL INDIRECT COSTS	\$ <u>1,059,800</u>
Contingencies (20% of direct and indirect costs)	\$ <u>869,900</u>
Total Turnkey Costs (direct+indirect+contingencies)	<u>5,219,500</u>
Land	<u>2,000</u>
Working capital (25% of total direct operating costs)	<u>219,200</u>
GRAND TOTAL (turnkey+land+working capital)	\$ <u>5,440,700</u>

^aQuote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE A-30. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING SUBBITUMINOUS COAL
WITH A THERMAL INPUT OF 22.0 MW
(75 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST	
Direct labor	\$ 210,600
Supervision	136,900
Maintenance labor	128,200
Maintenance materials	a
Replacement parts	144,000
Electricity	70,900
Steam	N.A.
Cooling water	N.A.
Process water	1,100
Fuel	165,600
Bottom ash disposal	14,700
Chemicals	4,900
Total direct cost	\$ 876,900
OVERHEAD	
Payroll (30% of direct labor	\$ 63,200
Plant (26% of labor, parts & maint.)	161,100
Total overhead costs	\$ 224,300
BY-PRODUCT CREDITS	N.A.
CAPITAL CHARGES	
G & A, taxes & insurance (4% of total turnkey costs)	\$ 208,800
Capital recovery factor (10.14 % of total turnkey costs)	529,300
Interest on working capital (10% of working capital)	21,900
Total capital charges	\$ 760,000
TOTAL ANNUALIZED COSTS	\$1,861,200 ✓
a Included with replacement parts.	
N.A. - Not applicable.	

TABLE A-31. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED WATER TUBE,
SPREADER-STOKER BOILER FIRING EASTERN MEDIUM-SULFUR COAL
WITH A THERMAL INPUT OF 22 MW
(75 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 678,600
Stack	80,000
Instrumentation	50,000
Stoker	156,600
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerators	15,900
Heaters	N.A.
Boiler feed pumps	25,300
Condensate systems	8,700
Water treating system	15,000
Chemical feed	1,400
Compressed air system	N.A.
Coal handling system	147,600
Ash disposal system	121,300
Thawing equipment	N.A.
Fuel-oil system	N.A.
Total Equipment Cost	\$1,300,400

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 438,500
Stack	20,000
Instrumentation	15,000
Stoker	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerators	3,500
Heaters	N.A.
Boiler feed pumps	5,500
Condensate system	1,300
Water treating system	2,500
Chemical feed	1,500
Coal handling system	156,600
Ash disposal system	62,600
Thawing equipment	N.A.
Fuel-oil system	N.A.

N.A. - Not applicable.

TABLE A-31. (continued)

INSTALLATION COSTS, DIRECT (cont.)

Foundations and supports	<u>83,500</u>
Ductwork (not incl. w/boiler)	<u>N.A.</u>
Piping	<u>52,200</u>
Insulation	<u>41,800</u>
Painting	<u>7,300</u>
Electrical	<u>75,000</u>
Buildings	<u>208,800</u>

Total installation cost	<u>\$1,175,600</u>
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TOTAL DIRECT COSTS

(equipment + installation)

\$2,476,000

INSTALLATION COSTS, INDIRECT

Engineering (10% of direct costs)	<u>\$ 247,600</u>
Construction and field expense (10% of direct costs)	<u>247,600</u>
Construction fees (10% of direct costs)	<u>247,600</u>
Start-up (2% of direct costs)	<u>49,500</u>
Performance tests (minimum \$2000)	<u>7,000</u>

TOTAL INDIRECT COSTS

\$ 799,300

Contingencies

(20% of direct and indirect costs)

\$ 655,100

Total Turnkey Costs

(direct+indirect+contingencies)

3,930,400

Land

2,000Working capital (25% of total direct
operating costs)259,800

GRAND TOTAL

(turnkey+land+working capital)

\$4,192,200

^aQuote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE A-32. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN MEDIUM-SULFUR COAL
WITH A THERMAL INPUT OF 22 MW
(75 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

Direct labor	\$ 210,600
Supervision	136,900
Maintenance labor	128,200
Maintenance materials	a
Replacement parts	104,400
Electricity	51,400
Steam	N.A.
Cooling water	N.A.
Process water	1,100
Fuel	374,500
Bottom ash disposal	27,300
Chemicals	4,900
Total direct cost	\$1,039,300

OVERHEAD

Payroll (30% of direct labor	\$ 63,200
Plant (26% of labor, parts & maint.)	150,800
Total overhead costs	\$ 214,000

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	\$ 157,200
Capital recovery factor (10.14 % of total turnkey costs)	398,500
Interest on working capital (10% of working capital)	26,000
Total capital charges	\$ 581,700

TOTAL ANNUALIZED COSTS \$1,835,000

a Included with replacement parts.
N.A. - Not applicable.

TABLE A-33. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN HIGH-SULFUR COAL WITH A THERMAL INPUT OF 44 MW (150 x 10⁶ Btu/h; 450 psig/600°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST ^a

Boiler (with fans and ducts)	\$ 1,753,800
Stack	300,000
Instrumentation	113,500
Stokers	227,600
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerator	21,600
Heaters	N.A.
Boiler feed pumps	44,500
Condensate systems	9,200
Water treating system	18,000
Chemical feed	1,500
Compressed air system	N.A.
Coal handling system	282,300
Ash disposal system	167,500
Thawing equipment	Incl. w/coal handling
Fuel-oil system	N.A.

Total Equipment Cost \$ 2,939,500

INSTALLATION COSTS, DIRECT

Boiler (including foundations and steel)	\$ 936,000
Stack	50,000
Instrumentation	25,000
Pulverizers	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerator	4,000
Heaters	N.A.
Boiler feed pumps	7,000
Condensate system	1,500
Water treating system	3,000
Chemical feed	1,500
Coal handling system	292,500 (incl. site prep)
Ash disposal system	117,000
Thawing equipment	Incl. w/coal handling
Fuel-oil system	N.A.

N.A. - Not applicable.

TABLE A-33. (continued)

INSTALLATION COSTS, DIRECT (cont.)

Foundations and supports	175,500
Ductwork (not incl. w/boiler)	N.A.
Piping	81,900
Insulation	87,800
Painting	11,700
Electrical	150,000
Buildings	409,500

Total Installation Costs	\$ 2,353,900
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TOTAL DIRECT COSTS

(Equipment + Installation)	\$ 5,293,400
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INSTALLATION COSTS, INDIRECT

Engineering (10% of direct costs)	\$ 529,300
Construction and field expense (10% of direct costs)	529,300
Construction fees (10% of direct costs)	529,300
Startup (2% of direct costs)	105,900
Performance tests	10,000

TOTAL INDIRECT COSTS	\$ 1,703,800
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Contingencies (20% of direct and indirect costs)	\$ 1,399,400
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Total turnkey costs (Direct + Indirect + Contingencies)	8,396,600
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Land	2,000
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Working capital (25% of total direct operating costs)	385,600
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GRAND TOTAL (Turnkey + Land + Working Capital)	\$ 8,784,200
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^a Quote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-34. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED
WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN HIGH-SULFUR
COAL WITH A THERMAL INPUT OF 44 MW
(150 x 10⁶ Btu/h; 450 psig/600°F design)

DIRECT COST	
Direct labor	\$ 315,900
Supervision	136,900
Maintenance labor	128,200
Maintenance materials	a
Replacement parts	234,000
Electricity	85,200
Steam	N.A.
Cooling water	N.A.
Process water	2,300
Fuel	583,400
Bottom ash disposal	50,500
Chemicals	6,000
Total direct cost	\$1,542,400
OVERHEAD	
Payroll (30% of direct labor)	\$ 94,800
Plant (26% of labor, parts & maint.)	211,900
Total overhead costs	\$ 306,700
BYPRODUCT CREDITS	N.A.
CAPITAL CHARGES	
G & A, taxes & insurance (4% of total turnkey costs)	\$ 335,900
Capital recovery factor (10.14% of total turnkey costs)	851,400
Interest on working capital (10% of working capital)	38,600
Total capital charges	\$1,225,900
TOTAL ANNUALIZED COSTS	\$3,075,000

^a Included with replacement parts.

N.A. - Not applicable.

TABLE A-35. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED,
WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN LOW-
SULFUR COAL WITH A THERMAL INPUT OF 44 MW
(150 x 10⁶ Btu/h; 450 psig/600°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST ^a

Boiler (with fans and ducts)	\$ 1,499,000
Stack	300,000
Instrumentation	113,500
Stokers	194,500
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerator	21,600
Heaters	N.A.
Boiler feed pumps	44,500
Condensate systems	9,200
Water treating system	18,000
Chemical feed	1,500
Compressed air system	N.A.
Coal handling system	241,300
Ash disposal system	143,200
Thawing equipment	Incl. w/coal handling
Fuel-oil system	N.A.

Total Equipment Cost

\$ 2,586,300

INSTALLATION COSTS, DIRECT

Boiler (including founda- tions and steel)	\$ 800,000
Stack	50,000
Instrumentation	25,000
Pulverizers	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerator	4,000
Heaters	N.A.
Boiler feed pumps	7,000
Condensate system	1,500
Water treating system	3,000
Chemical feed	1,500
Coal handling system	250,000 (incl. site prep.)
Ash disposal system	100,000
Thawing equipment	Incl. w/coal handling
Fuel-oil system	N.A.

N.A. - Not applicable.

TABLE A-35. (continued)

INSTALLATION COSTS, DIRECT (cont.)

Foundations and supports	150,000
Ductwork ~~k~~ (not incl. w/boiler)	N.A.
Piping	70,000
Insulation	75,000
Painting	10,000
Electrical	150,000
Buildings	350,000

Total Installation Costs \$ 2,047,000

TOTAL DIRECT COSTS
(Equipment + Installation) \$ 4,633,300

INSTALLATION COSTS, INDIRECT

Engineering (10% of direct costs)	\$ 463,300
Construction and field expense (10% of direct costs)	463,300
Construction fees (10% of direct costs)	463,300
Startup (2% of direct costs)	92,700
Performance tests (minimum \$2000)	10,000

TOTAL INDIRECT COSTS \$ 1,492,600

Contingencies
(20% of direct and indirect costs) \$ 1,225,200

Total turnkey costs
(Direct + Indirect + Contingencies) 7,351,100

Land 2,000

Working capital (25% of total direct
operating costs) 451,000

GRAND TOTAL
(Turnkey + Land + Working Capital) \$ 7,804,100 ✓

^a Quote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-36. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED,
WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN LOW-
SULFUR COAL WITH A THERMAL INPUT OF 44 MW
(150 x 10⁶ Btu/h; 450 psig/600°F design)

DIRECT COST	
Direct labor	\$ 315,900
Supervision	<u>136,900</u>
Maintenance labor	<u>128,200</u>
Maintenance materials	<u>a</u>
Replacement parts	<u>200,000</u>
Electricity	<u>72,800</u>
Steam	<u>N.A.</u>
Cooling water	<u>N.A.</u>
Process water	<u>2,300</u>
Fuel	<u>914,500</u>
Bottom ash disposal	<u>27,300</u>
Chemicals	<u>6,000</u>
Total direct cost	<u>\$1,803,900</u>
OVERHEAD	
Payroll (30% of direct labor)	\$ <u>94,800</u>
Plant (26% of labor, parts & maint.)	<u>203,100</u>
Total overhead costs	\$ <u>297,900</u>
BYPRODUCT CREDITS	<u>N.A.</u>
CAPITAL CHARGES	
G & A, taxes & insurance (4% of total turnkey costs)	\$ <u>294,000</u>
Capital recovery factor (10.14% of total turnkey costs)	<u>745,400</u>
Interest on working capital (10% of working capital)	<u>45,100</u>
Total capital charges	\$ <u>1,084,500</u>
TOTAL ANNUALIZED COSTS	<u>\$ 3,186,300</u>

^a Included with replacement parts.

N.A. - Not applicable.

TABLE A-37. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED,
WATER-TUBE, SPREADER-STOKER BOILER FIRING SUBBITUMINOUS
COAL WITH A THERMAL INPUT OF 44 MW
(150 x 10⁶ Btu/h; 450 psig/600°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans and ducts)	\$ 2,158,600
Stack	300,000
Instrumentation	113,500
Stokers	280,100
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerator	21,600
Heaters	N.A.
Boiler feed pumps	44,500
Condensate systems	9,200
Water treating system	18,000
Chemical feed	1,500
Compressed air system	N.A.
Coal handling system	347,500
Ash disposal system	206,200
Thawing equipment	Incl. w/coal handling
Fuel-oil system	N.A.

Total Equipment Cost \$ 3,500,700

INSTALLATION COSTS, DIRECT

Boiler (including founda- tions and steel)	\$ 1,152,000
Stack	50,000
Instrumentation	25,000
Pulverizers	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerator	4,000
Heaters	N.A.
Boiler feed pumps	7,000
Condensate system	1,500
Water treating system	3,000
Chemical feed	1,500
Coal handling system	360,000 (incl. site prep)
Ash disposal system	144,000
Thawing equipment	Incl. w/coal handling
Fuel-oil system	N.A.

N.A. - Not applicable.

TABLE A-37. (continued)

INSTALLATION COSTS, DIRECT (cont.)

Foundations and supports	216,000
Ductwork (not incl. w/boiler)	N.A.
Piping	100,800
Insulation	108,000
Painting	14,400
Electrical	150,000
Buildings	504,000

Total Installation Costs	\$ 2,841,200
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TOTAL DIRECT COSTS (Equipment + Installation)	\$ 6,341,900
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INSTALLATION COSTS, INDIRECT

Engineering (10% of direct costs)	\$ 634,200
Construction and field expense (10% of direct costs)	634,200
Construction fees (10% of direct costs)	634,200
Startup (2% of direct costs)	126,800
Performance tests (minimum \$2000)	10,000

TOTAL INDIRECT COSTS	\$ 2,039,400
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Contingencies (20% of direct and indirect costs)	\$ 1,676,300
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Total turnkey costs (Direct + Indirect + Contingencies)	10,057,600
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Land	2,000
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Working capital (25% of total direct operating costs)	336,200
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GRAND TOTAL (Turnkey + Land + Working Capital)	\$10,395,800
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^a Quote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-38. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED,
WATER-TUBE, SPREADER-STOKER BOILER FIRING SUBBITUMINOUS
COAL WITH A THERMAL INPUT OF 44 MW
(150 x 10⁶ Btu/h; 450 psig/600°F design)

DIRECT COST	
Direct labor	\$ 315,900
Supervision	136,900
Maintenance labor	128,200
Maintenance materials	a
Replacement parts	288,000
Electricity	104,800
Steam	N.A.
Cooling water	N.A.
Process water	2,300
Fuel	331,100
Bottom ash disposal	31,500
Chemicals	6,000
Total direct cost	\$1,344,700
OVERHEAD	
Payroll (30% of direct labor)	\$ 94,800
Plant (26% of labor, parts & maint.)	225,900
Total overhead costs	\$ 320,700
BYPRODUCT CREDITS	N.A.
CAPITAL CHARGES	
G & A, taxes & insurance (4% of total turnkey costs)	\$ 402,300
Capital recovery factor (10.14% of total turnkey costs)	1,019,800
Interest on working capital (10% of working capital)	33,600
Total capital charges	\$ 1,455,700
TOTAL ANNUALIZED COSTS	\$ 3,121,100

^a Included with replacement parts.

N.A. - Not applicable.

TABLE A-39. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN MEDIUM-SULFUR COAL WITH A THERMAL INPUT OF 44.0 MW (150 x 10⁶ Btu/h; 450 psig/600°F design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST ^a

Boiler (with fans & ducts)	\$ 1,565,000
Stack	300,000
Instrumentation	113,500
Stoker	203,000
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerators	21,600
Heaters	N.A.
Boiler feed pumps	44,500
Condensate systems	9,200
Water treating system	18,000
Chemical feed	1,500
Compressed air system	N.A.
Coal handling system	252,000
Ash disposal system	150,000
Thawing equipment	Incl. w/coal handling
Fuel-oil system	N.A.
Total Equipment Cost	\$ 2,678,300

INSTALLATION COST, DIRECT

Boiler (including foundations and steel)	\$ 835,000
Stack	50,000
Instrumentation	25,000
Stoker	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerators	4,000
Heaters	N.A.
Boiler feed pumps	7,000
Condensate system	1,500
Water treating system	3,000
Chemical feed	1,500
Coal handling system	261,000
Ash disposal system	104,000
Thawing equipment	Incl. w/coal handling
Fuel-oil system	N.A.

N.A. - Not applicable.

TABLE A-39. (continued)

INSTALLATION COSTS, DIRECT (cont.)	
Foundations and supports	157,000
Ductwork (not incl. w/boiler)	N.A.
Piping	73,000
Insulation	78,000
Painting	10,000
Electrical	150,000
Buildings	365,000
Total installation cost	\$ 2,125,000
TOTAL DIRECT COSTS (equipment + installation)	\$ 4,803,300
INSTALLATION COSTS, INDIRECT	
Engineering (10% of direct costs)	\$ 480,300
Construction and field expense (10% of direct costs)	480,300
Construction fees (10% of direct costs)	480,300
Start-up (2% of direct costs)	96,100
Performance tests (minimum \$2000)	10,000
TOTAL INDIRECT COSTS	\$ 1,547,000
Contingencies (20% of direct and indirect costs)	\$ 1,270,100
Total Turnkey Costs (direct+indirect+contingencies)	7,620,400
Land	2,000
Working capital (25% of total direct operating costs)	419,500
GRAND TOTAL (turnkey+land+working capital)	\$ 8,041,900

^aQuote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-40. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN MEDIUM-SULFUR COAL
WITH A THERMAL INPUT OF 44.0 MW
(150 x 10⁶ Btu/h; 450 psig/600°F design)

DIRECT COST

Direct labor	\$ 315,900
Supervision	<u>136,900</u>
Maintenance labor	<u>128,200</u>
Maintenance materials	<u>a</u>
Replacement parts	<u>208,800</u>
Electricity	<u>76,100</u>
Steam	<u>N.A.</u>
Cooling water	<u>N.A.</u>
Process water	<u>2,300</u>
Fuel	<u>749,000</u>
Bottom ash disposal	<u>54,700</u>
Chemicals	<u>6,000</u>
Total direct cost	<u>\$1,677,900</u>

OVERHEAD

Payroll (30% of direct labor)	\$ <u>94,800</u>
Plant (26% of labor, parts & maint.)	<u>205,300</u>
Total overhead costs	<u>\$ 300,100</u>

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	\$ <u>304,800</u>
Capital recovery factor (10.14 % of total turnkey costs)	<u>772,700</u>
Interest on working capital (10% of working capital)	<u>42,000</u>
Total capital charges	<u>\$1,119,500</u>

TOTAL ANNUALIZED COSTS	<u>\$3,097,500</u>
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a Included with replacement parts.
N.A. - Not applicable.

TABLE A-41. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN HIGH-SULFUR COAL WITH A THERMAL INPUT OF 58.6 MW (200 x 10⁶ Btu/h; 750 psig/750°F design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ <u>2,049,000</u>
Stack	<u>375,000</u>
Instrumentation	<u>123,700</u>
Stoker	<u>258,000</u>
Feeders	<u>117,000</u>
Crushers	Incl. w/coal handling
Deaerators	<u>28,000</u>
Heaters	<u>N.A.</u>
Boiler feed pumps	<u>58,000</u>
Condensate systems	<u>18,000</u>
Water treating system	<u>20,000</u>
Chemical feed	<u>1,500</u>
Compressed air system	<u>18,000</u>
Coal handling system	<u>316,000</u>
Ash disposal system	<u>205,000</u>
Thawing equipment	Incl. w/coal handling
Fuel-oil system	<u>N.A.</u>
Total Equipment Cost	\$ <u>3,587,200</u>

INSTALLATION COST, DIRECT

Boiler (including foundations and steel)	\$ <u>1,082,000</u>
Stack	<u>65,000</u>
Instrumentation	<u>40,000</u>
Stoker	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerators	<u>6,000</u>
Heaters	<u>N.A.</u>
Boiler feed pumps	<u>8,500</u>
Condensate system	<u>2,000</u>
Water treating system	<u>3,500</u>
Chemical feed	<u>1,500</u>
Coal handling system	<u>322,000</u>
Ash disposal system	<u>146,000</u>
Thawing equipment	Incl. w/coal handling
Fuel-oil system	<u>N.A.</u>

N.A. - Not applicable.

TABLE A-41. (continued)

INSTALLATION COSTS, DIRECT (cont.)

Foundations and supports	<u>199,000</u>
Ductwork (not incl. w/boiler)	<u>N.A.</u>
Piping	<u>100,000</u>
Insulation	<u>100,000</u>
Painting	<u>12,000</u>
Electrical	<u>165,000</u>
Buildings	<u>468,000</u>

Total installation cost	<u>\$2,720,500</u>
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TOTAL DIRECT COSTS

(equipment + installation)	<u>\$6,307,700</u>
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INSTALLATION COSTS, INDIRECT

Engineering (10% of direct costs)	<u>\$ 630,800</u>
Construction and field expense (10% of direct costs)	<u>630,800</u>
Construction fees (10% of direct costs)	<u>630,800</u>
Start-up (2% of direct costs)	<u>126,200</u>
Performance tests (minimum \$2000)	<u>10,000</u>

TOTAL INDIRECT COSTS	<u>\$2,028,600</u>
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Contingencies

(20% of direct and indirect costs)	<u>\$1,667,300</u>
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Total Turnkey Costs

(direct+indirect+contingencies)	<u>10,003,600</u>
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Land

<u>2,000</u>

Working capital (25% of total direct operating costs)	<u>504,600</u>
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GRAND TOTAL

(turnkey+land+working capital)	<u>\$10,510,200</u>
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^aQuote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-42. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN HIGH-SULFUR COAL
WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750°F design)

DIRECT COST

Direct labor	\$ 421,200
Supervision	136,900
Maintenance labor	192,200
Maintenance materials	a
Replacement parts	304,200
Electricity	110,200
Steam	N.A.
Cooling water	N.A.
Process water	3,000
Fuel	777,900
Bottom ash disposal	65,200
Chemicals	7,500
Total direct cost	\$ 2,018,300

OVERHEAD

Payroll (30% of direct labor	\$ 126,400
Plant (26% of labor, parts & maint.)	274,200
Total overhead costs	\$ 400,600

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	\$ 400,100
Capital recovery factor (10.14% of total turnkey costs)	1,014,400
Interest on working capital (10% of working capital)	50,500
Total capital charges	\$ 1,465,000

TOTAL ANNUALIZED COSTS \$3,883,900

a Included with replacement parts.

N.A. - Not applicable.

TABLE A-43. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN LOW-SULFUR COAL
WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 1,751,200
Stack	375,000
Instrumentation	123,700
Stoker	220,800
Feeders	100,000
Crushers	Incl. w/coal handling
Deaerators	28,000
Heaters	N.A.
Boiler feed pumps	58,000
Condensate systems	18,000
Water treating system	20,000
Chemical feed	1,500
Compressed air system	15,000
Coal handling system	270,000
Ash disposal system	175,000
Thawing equipment	Incl. w/coal handling
Fuel-oil system	N.A.

Total Equipment Cost \$ 3,156,200

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 925,000
Stack	65,000
Instrumentation	40,000
Stoker	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerators	6,000
Heaters	N.A.
Boiler feed pumps	8,500
Condensate system	2,000
Water treating system	3,500
Chemical feed	1,500
Coal handling system	275,000
Ash disposal system	125,000
Thawing equipment	Incl. w/coal handling
Fuel-oil system	N.A.

N.A. - Not applicable.

TABLE A-43. (continued)

INSTALLATION COSTS, DIRECT (cont.)

Foundations and supports	<u>170,000</u>
Ductwork (not incl. w/boiler)	<u>N.A.</u>
Piping	<u>85,000</u>
Insulation	<u>85,000</u>
Painting	<u>10,000</u>
Electrical	<u>165,000</u>
Buildings	<u>400,000</u>

Total installation cost	<u>\$ 2,366,500</u>
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TOTAL DIRECT COSTS

(equipment + installation)	<u>\$ 5,522,700</u>
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INSTALLATION COSTS, INDIRECT

Engineering (10% of direct costs)	<u>\$ 552,300</u>
Construction and field expense (10% of direct costs)	<u>552,300</u>
Construction fees (10% of direct costs)	<u>552,300</u>
Start-up (2% of direct costs)	<u>110,500</u>
Performance tests (minimum \$2000)	<u>10,000</u>

TOTAL INDIRECT COSTS	<u>\$ 1,777,400</u>
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Contingencies

(20% of direct and indirect costs)	<u>\$ 1,460,000</u>
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Total Turnkey Costs

(direct+indirect+contingencies)	<u>8,760,100</u>
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Land

<u>2,000</u>

Working capital (25% of total direct operating costs)	<u>593,100</u>
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GRAND TOTAL

(turnkey+land+working capital)	<u>\$9,355,200</u>
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^aQuote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-44. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN LOW-SULFUR COAL
WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750°F design)

DIRECT COST

Direct labor	\$ 421,200
Supervision	136,900
Maintenance labor	192,200
Maintenance materials	a
Replacement parts	260,000
Electricity	94,200
Steam	N.A.
Cooling water	N.A.
Process water	3,000
Fuel	1,219,400
Bottom ash disposal	37,800
Chemicals	7,500
Total direct cost	\$2,372,200

OVERHEAD

Payroll (30% of direct labor	\$ 126,400
Plant (26% of labor, parts & maint.)	262,700
Total overhead costs	\$ 389,100

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	\$ 350,400
Capital recovery factor (10.14 % of total turnkey costs)	888,300
Interest on working capital (10% of working capital)	59,300
Total capital charges	\$1,298,000

TOTAL ANNUALIZED COSTS

\$4,059,300

a Included with replacement parts.
N.A. - Not applicable.

TABLE A-45. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING SUBBITUMINOUS COAL WITH A THERMAL INPUT OF 58.6 MW (200 x 10⁶ Btu/h; 750 psig/750°F design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST ^a

Boiler (with fans & ducts)	\$ 2,522,000
Stack	375,000
Instrumentation	123,700
Stoker	318,000
Feeders	144,000
Crushers	Incl. w/coal handling
Deaerators	28,000
Heaters	N.A.
Boiler feed pumps	58,000
Condensate systems	18,000
Water treating system	20,000
Chemical feed	1,500
Compressed air system	22,000
Coal handling system	389,000
Ash disposal system	252,000
Thawing equipment	Incl. w/coal handling
Fuel-oil system	N.A.
Total Equipment Cost	\$ 4,271,200

INSTALLATION COST, DIRECT

Boiler (including foundations and steel)	\$ 1,332,000
Stack	65,000
Instrumentation	40,000
Stoker	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerators	6,000
Heaters	N.A.
Boiler feed pumps	8,500
Condensate system	2,000
Water treating system	3,500
Chemical feed	1,500
Coal handling system	396,000
Ash disposal system	180,000
Thawing equipment	Incl. w/coal handling
Fuel-oil system	N.A.

N.A. - Not applicable.

TABLE A-45. (continued)

INSTALLATION COSTS, DIRECT (cont.)

Foundations and supports	<u>245,000</u>
Ductwork (not incl. w/boiler)	<u>N.A.</u>
Piping	<u>122,000</u>
Insulation	<u>122,000</u>
Painting	<u>14,000</u>
Electrical	<u>165,000</u>
Buildings	<u>576,000</u>

Total installation cost	<u>\$3,278,500</u>
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TOTAL DIRECT COSTS

(equipment + installation)	<u>\$7,549,700</u>
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INSTALLATION COSTS, INDIRECT

Engineering (10% of direct costs)	<u>\$ 755,000</u>
Construction and field expense (10% of direct costs)	<u>755,000</u>
Construction fees (10% of direct costs)	<u>755,000</u>
Start-up (2% of direct costs)	<u>151,000</u>
Performance tests (minimum \$2000)	<u>10,000</u>

TOTAL INDIRECT COSTS	<u>\$2,426,000</u>
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Contingencies

(20% of direct and indirect costs)	<u>\$1,995,100</u>
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Total Turnkey Costs

(direct+indirect+contingencies)	<u>11,970,800</u>
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Land

<u>2,000</u>

Working capital (25% of total direct operating costs)	<u>438,600</u>
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GRAND TOTAL

(turnkey+land+working capital)	<u>\$12,411,400</u>
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^aQuote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-46. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING SUBBITUMINOUS COAL
WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750°F design)

DIRECT COST

Direct labor	\$ 421,200
Supervision	136,900
Maintenance labor	192,200
Maintenance materials	a
Replacement parts	374,400
Electricity	135,700
Steam	N.A.
Cooling water	N.A.
Process water	3,000
Fuel	441,500
Bottom ash disposal	42,000
Chemicals	7,500
Total direct cost	\$1,754,400

OVERHEAD

Payroll (30% of direct labor	\$ 126,400
Plant (26% of labor, parts & maint.)	292,400
Total overhead costs	\$ 418,800

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	\$ 478,800
Capital recovery factor (10.14 % of total turnkey costs)	1,213,800
Interest on working capital (10% of working capital)	43,900
Total capital charges	\$1,736,500

TOTAL ANNUALIZED COSTS

\$3,909,700

a Included with replacement parts.
N.A. - Not applicable.

TABLE A-47. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN MEDIUM-SULFUR COAL WITH A THERMAL INPUT OF 58.6 MW (200 x 10⁶ Btu/h; 750 psig/750°F design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 1,828,000
Stack	375,000
Instrumentation	123,700
Stoker	231,000
Feeders	104,000
Crushers	Incl. w/coal handling
Deaerators	28,000
Heaters	N.A.
Boiler feed pumps	58,000
Condensate systems	18,000
Water treating system	20,000
Chemical feed	1,500
Compressed air system	16,000
Coal handling system	282,000
Ash disposal system	183,000
Thawing equipment	Incl. w/coal handling
Fuel-oil system	N.A.
Total Equipment Cost	\$ 3,268,200

INSTALLATION COST, DIRECT

Boiler (including foundations and steel)	\$ 966,000
Stack	65,000
Instrumentation	40,000
Stoker	Incl. w/boiler
Feeders	Incl. w/coal handling
Crushers	Incl. w/coal handling
Deaerators	6,000
Heaters	N.A.
Boiler feed pumps	8,500
Condensate system	2,000
Water treating system	3,500
Chemical feed	1,500
Coal handling system	287,000
Ash disposal system	131,000
Thawing equipment	Incl. w/coal handling
Fuel-oil system	N.A.

N.A. - Not applicable.

TABLE A-47. (continued)

INSTALLATION COSTS, DIRECT (cont.)

Foundations and supports	178,000
Ductwork (not incl. w/boiler)	N.A.
Piping	89,000
Insulation	89,000
Painting	10,000
Electrical	165,000
Buildings	418,000

Total installation cost	\$ 2,459,500
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TOTAL DIRECT COSTS

(equipment + installation)	\$ 5,727,700
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INSTALLATION COSTS, INDIRECT

Engineering (10% of direct costs)	\$ 572,800
Construction and field expense (10% of direct costs)	572,800
Construction fees (10% of direct costs)	572,800
Start-up (2% of direct costs)	114,600
Performance tests (minimum \$2000)	10,000

TOTAL INDIRECT COSTS	\$ 1,843,000
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Contingencies

(20% of direct and indirect costs)	\$ 1,514,100
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Total Turnkey Costs

(direct+indirect+contingencies)	9,084,800
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Land

2,000

Working capital (25% of total direct operating costs)	550,700
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GRAND TOTAL

(turnkey+land+working capital)	\$ 9,637,500
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^aQuote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-48. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN MEDIUM-SULFUR COAL
WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750°F design)

DIRECT COST

Direct labor	\$ 421,200
Supervision	136,900
Maintenance labor	192,200
Maintenance materials	a
Replacement parts	271,400
Electricity	98,400
Steam	N.A.
Cooling water	N.A.
Process water	3,000
Fuel	998,600
Bottom ash disposal	73,600
Chemicals	7,500
Total direct cost	\$2,202,800

OVERHEAD

Payroll (30% of direct labor	\$ 126,400
Plant (26% of labor, parts & maint.)	265,600
Total overhead costs	\$ 392,000

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	\$ 363,400
Capital recovery factor (10.14 % of total turnkey costs)	921,200
Interest on working capital (10% of working capital)	55,100
Total capital charges	\$1,339,700

TOTAL ANNUALIZED COSTS

\$3,934,500

a Included with replacement parts.
N.A. - Not applicable.

TABLE A-49. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
HIGH-SULFUR COAL WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST ^a

Boiler (with fans and ducts)	\$ 2,492,100
Stack	365,000
Instrumentation	228,000
Pulverizers	613,100
Feeders	128,700
Crushers	Incl. w/coal handling
Deaerator	29,000
Heaters	Incl. w/boiler
Boiler feed pumps	58,000
Condensate systems	16,300
Water treating system	20,000
Chemical feed	1,500
Compressed air system	23,400
Coal handling system	308,800
Ash disposal system	210,600
Thawing equipment	Incl. w/coal handling
Fuel-oil system	N.A.

Total Equipment Cost

\$ 4,494,500

INSTALLATION COSTS, DIRECT

Boiler (including foundations and steel)	\$ 1,270,000
Stack	60,000
Instrumentation	35,000
Pulverizers	Incl. w/boiler
Feeders	Incl. w/boiler
Crushers	Incl. w/coal handling
Deaerator	5,000
Heaters	Incl. w/boiler
Boiler feed pumps	8,000
Condensate system	2,000
Water treating system	3,500
Chemical feed	1,500
Coal handling system	321,800 (incl. site prep.)
Ash disposal system	140,400
Thawing equipment	Incl. w/coal handling
Fuel-oil system	N.A.

N.A. - Not applicable.

TABLE A-49. (continued)

INSTALLATION COSTS, DIRECT (cont.)	
Foundations and supports	210,600
Duct work (not incl. w/boiler)	N.A.
Piping	93,600
Insulation	93,600
Painting	11,700
Electrical	160,000
Buildings	444,600
Total Installation Costs	\$ 2,861,300
TOTAL DIRECT COSTS (Equipment + Installation)	\$ 7,355,800
INSTALLATION COSTS, INDIRECT	
Engineering (10% of direct costs)	\$ 735,600
Construction and field expense (10% of direct costs)	735,600
Construction fees (10% of direct costs)	735,600
Startup (2% of direct costs)	147,100
Performance tests (minimum \$2000)	10,000
TOTAL INDIRECT COSTS	\$ 2,363,900
Contingencies (20% of direct and indirect costs)	\$ 1,943,900
Total turnkey costs (Direct + Indirect + Contingencies)	11,663,600
Land	2,000
Working capital (25% of total direct operating costs)	536,800
GRAND TOTAL (Turnkey + Land + Working Capital)	\$12,202,400

^a Quote from Babcock & Wilcox, Inc., August 17, 1978.
N.A. - Not applicable.

TABLE A-50. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED COAL-FIRED BOILER FIRING EASTERN
HIGH-SULFUR COAL WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750°F design)

DIRECT COST	
Direct labor	\$ 421,200
Supervision	136,900
Maintenance labor	192,200
Maintenance materials	a
Replacement parts	292,500
Electricity	278,300
Steam	N.A.
Cooling water	N.A.
Process water	3,000
Fuel	777,900
Bottom ash disposal	37,800
Chemicals	7,500
Total direct cost	\$2,147,300
OVERHEAD	
Payroll (30% of direct labor)	\$ 126,400
Plant (26% of labor, parts & maint.)	271,100
Total overhead costs	\$ 397,500
BYPRODUCT CREDITS	N.A.
CAPITAL CHARGES	
G & A, taxes & insurance (4% of total turnkey costs)	\$ 466,500
Capital recovery factor (10.14% of total turnkey costs)	1,182,700
Interest on working capital (10% of working capital)	53,700
Total capital charges	\$1,702,900
TOTAL ANNUALIZED COSTS	\$4,247,700

^a Included with replacement parts.

N.A. - Not applicable.

TABLE A-51. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
LOW-SULFUR COAL WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750°F design)

CAPITAL COSTS
DATE OF ESTIMATE

June 30, 1978

(FOR COSTS INDEXING)

EQUIPMENT COST ^a

Boiler (with fans and ducts)	\$ 2,130,000
Stack	365,000
Instrumentation	228,000
Pulverizers	524,500
Feeders	110,000
Crushers	Incl. w/coal handling
Deaerator	29,000
Heaters	Incl. w/boiler
Boiler feed pumps	58,000
Condensate systems	16,300
Water treating system	20,000
Chemical feed	1,500
Compressed air system	20,000
Coal handling system	263,900
Ash disposal system	180,000
Thawing equipment	Incl. w/coal handling
Fuel-oil system	N.A.

Total Equipment Cost

\$ 3,946,200

INSTALLATION COSTS, DIRECT

Boiler (including founda- tions and steel)	\$ 1,085,000
Stack	60,000
Instrumentation	35,000
Pulverizers	Incl. w/boiler
Feeders	Incl. w/boiler
Crushers	Incl. w/coal handling
Deaerator	5,000
Heaters	Incl. w/boiler
Boiler feed pumps	8,000
Condensate system	2,000
Water treating system	3,500
Chemical feed	1,500
Coal handling system	275,000 (incl. site prep.)
Ash disposal system	120,000
Thawing equipment	Incl. w/coal handling
Fuel-oil system	N.A.

N.A. - Not applicable.

TABLE A-51. (continued)

INSTALLATION COSTS, DIRECT (cont.)	
Foundations and supports	180,000
Duct work (not incl. w/boiler)	N.A.
Piping	80,000
Insulation	80,000
Painting	10,000
Electrical	160,000
Buildings	380,000
Total Installation Costs	\$ 2,485,000
TOTAL DIRECT COSTS (Equipment + Installation)	\$ 6,431,200
INSTALLATION COSTS, INDIRECT	
Engineering (10% of direct costs)	\$ 643,100
Construction and field expense (10% of direct costs)	643,100
Construction fees (10% of direct costs)	643,100
Startup (2% of direct costs)	128,600
Performance tests (minimum \$2000)	10,000
TOTAL INDIRECT COSTS	\$ 2,067,900
Contingencies (20% of direct and indirect costs)	\$ 1,699,800
Total turnkey costs (Direct + Indirect + Contingencies)	10,198,900
Land	2,000
Working capital (25% of total direct operating costs)	622,300
GRAND TOTAL (Turnkey + Land + Working Capital)	\$10,823,200

^a Quote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-52. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED,
WATER-TUBE PULVERIZED-COAL-FIRED BOILER FIRING EASTERN LOW-SULFUR
COAL WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750°F design)

DIRECT COST	
Direct labor	\$ 421,200
Supervision	136,900
Maintenance labor	192,200
Maintenance materials	a
Replacement parts	250,000
Electricity	237,900
Steam	N.A.
Cooling water	N.A.
Process water	3,000
Fuel	1,219,400
Bottom ash disposal	21,000
Chemicals	7,500
Total direct cost	\$2,489,100
OVERHEAD	
Payroll (30% of direct labor)	\$ 126,400
Plant (26% of labor, parts & maint.)	260,100
Total overhead costs	\$ 386,500
BYPRODUCT CREDITS	
	N.A.
CAPITAL CHARGES	
G & A, taxes & insurance (4% of total turnkey costs)	\$ 408,000
Capital recovery factor (10.14% of total turnkey costs)	1,034,200
Interest on working capital (10% of working capital)	62,200
Total capital charges	\$1,504,400
TOTAL ANNUALIZED COSTS	\$4,380,000

^a Included with replacement parts.

N.A. - Not applicable.

TABLE A-53. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED, WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING SUBBITUMINOUS COAL WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750° F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST ^a

Boiler (with fans and ducts)	\$ 3,067,200
Stack	365,000
Instrumentation	228,000
Pulverizers	754,600
Feeders	158,400
Crushers	Incl. w/coal handling
Deaerator	29,000
Heaters	Incl. w/boiler
Boiler feed pumps	58,000
Condensate systems	16,300
Water treating system	20,000
Chemical feed	1,500
Compressed air system	28,800
Coal handling system	380,000
Ash disposal system	259,200
Thawing equipment	Incl. w/coal handling
Fuel-oil system	N.A.
Total Equipment Cost	\$ 5,366,000

INSTALLATION COSTS, DIRECT

Boiler (including foundations and steel)	\$ 1,560,000
Stack	60,000
Instrumentation	35,000
Pulverizers	Incl. w/boiler
Feeders	Incl. w/boiler
Crushers	Incl. w/coal handling
Deaerator	5,000
Heaters	Incl. w/boiler
Boiler feed pumps	8,000
Condensate system	2,000
Water treating system	3,500
Chemical feed	1,500
Coal handling system	396,000
Ash disposal system	172,800
Thawing equipment	Incl. w/coal handling
Fuel-oil system	N.A.

N.A. - Not applicable.

TABLE A-53. (continued)

INSTALLATION COSTS, DIRECT (cont.)

Foundations and supports	259,200
Duct work (not incl. w/boiler)	N.A.
Piping	115,200
Insulation	115,200
Painting	14,400
Electrical	160,000
Buildings	547,200

Total Installation Costs	\$ 3,455,000
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TOTAL DIRECT COSTS (Equipment + Installation)	\$ 8,821,000
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INSTALLATION COSTS, INDIRECT

Engineering (10% of direct costs)	\$ 882,100
Construction and field expense (10% of direct costs)	882,100
Construction fees (10% of direct costs)	882,100
Startup (2% of direct costs)	176,400
Performance tests (minimum \$2000)	10,000

TOTAL INDIRECT COSTS	\$ 2,832,700
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Contingencies (20% of direct and indirect costs)	\$ 2,330,700
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Total turnkey costs (Direct + Indirect + Contingencies)	13,984,400
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Land	2,000
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Working capital (25% of total direct operating costs)	482,000
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GRAND TOTAL (Turnkey + Land + Working Capital)	\$ 14,468,400
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^a Quote from Babcock & Wilcox, Inc., August 17, 1978.
N.A. - Not applicable.

TABLE A-54. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING SUBBITUMINOUS
COAL WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750°F design)

DIRECT COST

Direct labor	\$ 421,200
Supervision	136,900
Maintenance labor	192,200
Maintenance materials	a
Replacement parts	360,000
Electricity	342,500
Steam	N.A.
Cooling water	N.A.
Process water	3,000
Fuel	441,500
Bottom ash disposal	23,100
Chemicals	7,500
Total direct cost	\$1,927,900

OVERHEAD

Payroll (30% of direct labor)	\$ 126,400
Plant (26% of labor, parts & maint.)	288,700
Total overhead costs	\$ 415,100

BYPRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	\$ 559,400
Capital recovery factor (10.14% of total turnkey costs)	1,418,000
Interest on working capital (10% of working capital)	48,200
Total capital charges	\$2,025,600

TOTAL ANNUALIZED COSTS

\$4,368,600

^a Included with replacement parts.

N.A. - Not applicable.

TABLE A-55. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
MEDIUM-SULFUR COAL WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/hr; 750 psig/750°F design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 2,224,000
Stack	365,000
Instrumentation	228,000
Pulverizers	548,000
Feeders	115,000
Crushers	incl. w/coal handling
Deaerators	29,000
Heaters	incl. w/boiler
Boiler feed pumps	58,000
Condensate systems	16,300
Water treating system	20,000
Chemical feed	1,500
Compressed air system	21,000
Coal handling system	276,000
Ash disposal system	188,000
Thawing equipment	incl w/coal handling
Fuel-oil system	N.A.
Total Equipment Cost	\$ 4,089,800

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 1,133,000
Stack	60,000
Instrumentation	35,000
Pulverizers	incl. w/boiler
Feeders	incl. w/boiler
Crushers	incl. w/coal handling
Deaerators	5,000
Heaters	incl. w/boiler
Boiler feed pumps	8,000
Condensate system	2,000
Water treating system	3,500
Chemical feed	1,500
Coal handling system	287,000
Ash disposal system	125,000
Thawing equipment	incl. w/coal handling
Fuel-oil system	N.A.

N.A. - Not applicable.

TABLE A-55. (continued)

INSTALLATION COSTS, DIRECT (cont.)	
Foundations and supports	188,000
Ductwork (not incl. w/boiler)	N.A.
Piping	84,000
Insulation	84,000
Painting	10,000
Electrical	160,000
Buildings	397,000
Total installation cost	\$ 2,583,000
TOTAL DIRECT COSTS (equipment + installation)	\$ 6,672,800
INSTALLATION COSTS, INDIRECT	
Engineering (10% of direct costs)	\$ 667,300
Construction and field expense (10% of direct costs)	667,300
Construction fees (10% of direct costs)	667,300
Start-up (2% of direct costs)	133,500
Performance tests (minimum \$2000)	10,000
TOTAL INDIRECT COSTS	\$ 2,145,400
Contingencies (20% of direct and indirect costs)	\$ 1,763,600
Total Turnkey Costs (direct+indirect+contingencies)	10,581,800
Land	2,000
Working capital (25% of total direct operating costs)	577,700
GRAND TOTAL (turnkey+land+working capital)	\$11,161,500

^aQuote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-56. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
MEDIUM-SULFUR COAL WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/hr; 750 psig/750°F design)

DIRECT COST

Direct labor	\$ 421,200
Supervision	136,900
Maintenance labor	192,200
Maintenance materials	a
Replacement parts	261,000
Electricity	248,300
Steam	N.A.
Cooling water	N.A.
Process water	3,000
Fuel	998,600
Bottom ash disposal	42,000
Chemicals	7,500
Total direct cost	<u>\$2,310,700</u>

OVERHEAD

Payroll (30% of direct labor	\$ 126,400
Plant (26% of labor, parts & maint.)	262,900
Total overhead costs	<u>\$ 389,300</u>

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	\$ 423,300
Capital recovery factor (10.14 % of total turnkey costs)	<u>1,073,000</u>
Interest on working capital (10% of working capital)	57,800
Total capital charges	<u>\$1,554,100</u>

TOTAL ANNUALIZED COSTS	<u><u>\$4,254,100</u></u>
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a Included with replacement parts.
N.A. - Not applicable.

TABLE A-57. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
HIGH-SULFUR COAL WITH A THERMAL INPUT OF 117.2 MW
(400 x 10⁶ Btu/hr; 750 psig/750°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 4,002,300
Stack	650,000
Instrumentation	378,600
Pulverizers	982,800
Feeders	209,300
Crushers	Incl. w/coal handling
Deaerator	60,000
Heaters	Incl. w/boiler
Boiler feed pumps	150,000
Condensate systems	25,000
Water treating system	60,000
Chemical feed	4,000
Compressed air system	46,800
Coal handling system	1,170,000
Ash disposal system	386,100
Thawing equipment	Incl. w/coal handling
Fuel-oil system	N.A.
Total Equipment Cost	\$ 8,124,900

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 2,538,900
Stack	Incl. w/equipment
Instrumentation	110,000
Pulverizers	Incl. w/boiler
Feeders	Incl. w/boiler
Crushers	Incl. w/coal handling
Deaerator	12,000
Heaters	Incl. w/boiler
Boiler feed pumps	18,000
Condensate system	10,000
Water treating system	16,000
Chemical feed	2,000
Coal handling system	737,100
Ash disposal system	304,200
Thawing equipment	Incl. w/coal handling
Fuel-oil system	N.A.

N.A. - Not applicable.

TABLE A-57.(continued)

INSTALLATION COSTS, DIRECT (cont.)

Foundations and supports	<u>386,000</u>
Duct work (not incl. w/boiler)	<u>N.A.</u>
Piping	<u>146,000</u>
Insulation	<u>129,000</u>
Painting	<u>19,000</u>
Electrical	<u>340,000</u>
Buildings	<u>761,000</u>
Total installation cost	<u>\$ 5,529,200</u>

TOTAL DIRECT COSTS

(equipment + installation)

\$ 13,654,100

INSTALLATION COSTS, INDIRECT

Engineering	
(10% of direct costs)	<u>\$ 1,365,400</u>
Construction and field expense	
(10% of direct costs)	<u>1,365,400</u>
Construction fees	
(10% of direct costs)	<u>1,365,400</u>
Startup (2% of direct costs)	<u>273,100</u>
Performance tests (minimum \$2000)	<u>15,000</u>

\$ 4,384,300

TOTAL INDIRECT COSTS

Contingencies

(20% of direct and indirect costs)

\$ 3,607,700

Total Turnkey Costs

(direct+indirect+contingencies)

21,646,100

Land

4,000

Working capital (25% of total direct operating costs)

987,900

GRAND TOTAL

(turnkey+land+working capital)

\$ 22,638,000^a Quote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-58. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
HIGH-SULFUR COAL WITH A THERMAL INPUT OF 117.2 MW
(400 x 10⁶ Btu/hr; 750 psig/750°F design)

DIRECT COST	
Direct labor	\$ 737,100
Supervision	205,400
Maintenance labor	384,500
Maintenance materials	^a
Replacement parts	409,500
Electricity	561,600
Steam	N.A.
Cooling water	N.A.
Process water	6,100
Fuel	1,555,800
Bottom ash disposal	75,500
Chemicals	16,000
Total direct cost	\$ 3,951,500
OVERHEAD	
Payroll (30% of direct labor)	\$ 221,100
Plant (26% of labor, parts & maint.)	451,500
Total overhead costs	\$ 672,600
BYPRODUCT CREDITS	
	N.A.
CAPITAL CHARGES	
G & A, taxes & insurance (4% of total turnkey costs)	\$ 865,800
Capital recovery factor (10.14% of total turnkey costs)	2,194,900
Interest on working capital (10% of working capital)	98,800
Total capital charges	\$ 3,159,500
TOTAL ANNUALIZED COSTS	\$ 7,783,600

^aIncluded in replacement parts.

N.A. - Not Applicable

TABLE A-59. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
LOW-SULFUR COAL WITH A THERMAL INPUT OF 117.2 MW
(400 x 10⁶ Btu/hr; 750 psig/750°F design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 3,420,800
Stack	650,000
Instrumentation	378,600
Pulverizers	840,000
Feeders	178,900
Crushers	Incl. w/coal handling
Deaerator	60,000
Heaters	Incl. w/boiler
Boiler feed pumps	150,000
Condensate systems	25,000
Water treating system	60,000
Chemical feed	4,000
Compressed air system	40,000
Coal handling system	1,000,000
Ash disposal system	330,000
Thawing equipment	Incl. w/coal handling
Fuel-oil system	N.A.
Total Equipment Cost	\$ 7,137,300

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 2,170,000
Stack	Incl. w/equipment
Instrumentation	110,000
Pulverizers	Incl. w/boiler
Feeders	Incl. w/boiler
Crushers	Incl. w/coal handling
Deaerator	12,000
Heaters	Incl. w/boiler
Boiler feed pumps	18,000
Condensate system	10,000
Water treating system	16,000
Chemical feed	2,000
Coal handling system	630,000
Ash disposal system	260,000
Thawing equipment	Incl. w/coal handling
Fuel-oil system	N.A.

N.A. - Not applicable.

TABLE A-59. (continued)

INSTALLATION COSTS, DIRECT (cont.)	
Foundations and supports	330,000
Duct work (not incl. w/boiler)	N.A.
Piping	125,000
Insulation	110,000
Painting	16,000
Electrical	340,000
Buildings	650,000
Total installation cost	\$ 4,799,000
TOTAL DIRECT COSTS (equipment + installation)	\$11,936,300
INSTALLATION COSTS, INDIRECT	
Engineering (10% of direct costs)	\$ 1,193,600
Construction and field expense (10% of direct costs)	1,193,600
Construction fees (10% of direct costs)	1,193,600
Startup (2% of direct costs)	238,700
Performance tests (minimum \$2000)	15,000
TOTAL INDIRECT COSTS	\$ 3,834,500
Contingencies (20% of direct and indirect costs)	\$ 3,154,200
Total Turnkey Costs (direct+indirect+contingencies)	18,925,000
Land	4,000
Working capital (25% of total direct operating costs)	1,165,000
GRAND TOTAL (turnkey+land+working capital)	\$20,094,000 ✓

^a Quote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-60. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
LOW-SULFUR COAL WITH A THERMAL INPUT OF 117.2 MW
(400 x 106 Btu/hr; 750 psig/750°F design)

DIRECT COST

Direct labor	\$ 737,100
Supervision	205,400
Maintenance labor	384,500
Maintenance materials	a
Replacement parts	350,000
Electricity	480,000
Steam	N.A.
Cooling water	N.A.
Process water	6,100
Fuel	2,438,800
Bottom ash disposal	42,000
Chemicals	16,000
Total direct cost	\$ 4,659,900

OVERHEAD

Payroll (30% of direct labor)	\$ 221,100
Plant (26% of labor, parts & maint.)	436,000
Total overhead costs	\$ 657,100

BYPRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	\$ 757,000
Capital recovery factor (10.14% of total turnkey costs)	1,919,000
Interest on working capital (10% of working capital)	116,500
Total capital charges	\$ 2,792,500

TOTAL ANNUALIZED COSTS

\$ 8,109,500

^aIncluded with replacement parts.

N.A. - Not Applicable

TABLE A-61. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING
SUBBITUMINOUS COAL WITH A THERMAL INPUT OF 117.2 MW
(400 x 10⁶ Btu/hr; 750 psig/750°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST ^a

Boiler (with fans & ducts)	\$ <u>4,926,000</u>
Stack	<u>650,000</u>
Instrumentation	<u>378,600</u>
Pulverizers	<u>1,209,600</u>
Feeders	<u>257,600</u>
Crushers	Incl. w/coal handling
Deaerator	<u>60,000</u>
Heaters	Incl. w/boiler
Boiler feed pumps	<u>150,000</u>
Condensate systems	<u>25,000</u>
Water treating system	<u>60,000</u>
Chemical feed	<u>4,000</u>
Compressed air system	<u>57,600</u>
Coal handling system	<u>1,440,000</u>
Ash disposal system	<u>475,200</u>
Thawing equipment	Incl. w/coal handling
Fuel-oil system	<u>N.A.</u>
Total Equipment Cost	\$ <u>9,693,600</u>

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ <u>3,124,800</u>
Stack	Incl. w/equipment
Instrumentation	<u>110,000</u>
Pulverizers	Incl. w/boiler
Feeders	Incl. w/boiler
Crushers	Incl. w/coal handling
Deaerator	<u>12,000</u>
Heaters	Incl. w/boiler
Boiler feed pumps	<u>18,000</u>
Condensate system	<u>10,000</u>
Water treating system	<u>16,000</u>
Chemical feed	<u>2,000</u>
Coal handling system	<u>907,200</u>
Ash disposal system	<u>374,400</u>
Thawing equipment	Incl. w/coal handling
Fuel-oil system	<u>N.A.</u>

N.A. - Not applicable.

TABLE A-61.(continued)

INSTALLATION COSTS, DIRECT (cont.)	
Foundations and supports	<u>475,000</u>
Duct work (not incl. w/boiler)	<u>N.A.</u>
Piping	<u>180,000</u>
Insulation	<u>158,000</u>
Painting	<u>23,000</u>
Electrical	<u>340,000</u>
Buildings	<u>936,000</u>
Total installation cost	<u>\$ 6,686,400</u>
TOTAL DIRECT COSTS (equipment + installation)	<u>\$16,380,000</u>
INSTALLATION COSTS, INDIRECT	
Engineering (10% of direct costs)	<u>\$ 1,638,000</u>
Construction and field expense (10% of direct costs)	<u>1,638,000</u>
Construction fees (10% of direct costs)	<u>1,638,000</u>
Startup (2% of direct costs)	<u>327,600</u>
Performance tests (minimum \$2000)	<u>15,000</u>
TOTAL INDIRECT COSTS	<u>\$ 5,256,600</u>
Contingencies (20% of direct and indirect costs)	<u>\$ 4,327,300</u>
Total Turnkey Costs (direct+indirect+contingencies)	<u>25,963,900</u>
Land	<u>4,000</u>
Working capital (25% of total direct operating costs)	<u>868,700</u>
GRAND TOTAL (turnkey+land+working capital)	<u>\$ 26,836,600</u>

^a Quote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-62. ESTIMATED ANNUALIZED COSTS FOR A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING
SUBBITUMINOUS COAL WITH A THERMAL INPUT OF 117.2 MW
(400 x 10⁶ Btu/hr; 750 psig/750°F design)

DIRECT COST	
Direct labor	\$ 737,100
Supervision	205,400
Maintenance labor	384,500
Maintenance materials	a
Replacement parts	504,000
Electricity	691,200
Steam	N.A.
Cooling water	N.A.
Process water	6,100
Fuel	883,000
Bottom ash disposal	47,300
Chemicals	16,000
Total direct cost	\$ 3,474,600
OVERHEAD	
Payroll (30% of direct labor)	\$ 221,100
Plant (26% of labor, parts & maint.)	476,100
Total overhead costs	\$ 697,200
BYPRODUCT CREDITS	N.A.
CAPITAL CHARGES	
G & A, taxes & insurance (4% of total turnkey costs)	\$ 1,038,600
Capital recovery factor (10.14% of total turnkey costs)	2,632,700
Interest on working capital (10% of working capital)	86,900
Total capital charges	\$ 3,758,200
TOTAL ANNUALIZED COSTS	\$ 7,930,000

^aIncluded in replacement parts.

N.A. - Not Applicable

TABLE A-63. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED, WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN MEDIUM-SULFUR COAL WITH A THERMAL INPUT OF 117.2 MW (400 x 10⁶ Btu/hr; 750 psig/750°F design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 3,571,300
Stack	<u>650,000</u>
Instrumentation	<u>378,600</u>
Pulverizers	<u>877,000</u>
Feeders	<u>186,800</u>
Crushers	<u>Incl. w/coal handling</u>
Deaerator	<u>60,000</u>
Heaters	<u>Incl. w/boiler</u>
Boiler feed pumps	<u>150,000</u>
Condensate systems	<u>25,000</u>
Water treating system	<u>60,000</u>
Chemical feed	<u>4,000</u>
Compressed air system	<u>41,800</u>
Coal handling system	<u>1,044,000</u>
Ash disposal system	<u>344,500</u>
Thawing equipment	<u>Incl. w/coal handling</u>
Fuel-oil system	<u>N.A.</u>
Total Equipment Cost	\$ 7,393,000

INSTALLATION COST, DIRECT

Boiler (including foundations and steel)	\$ 2,265,500
Stack	<u>Incl. w/equipment</u>
Instrumentation	<u>110,000</u>
Pulverizers	<u>Incl. w/boiler</u>
Feeders	<u>Incl. w/boiler</u>
Crushers	<u>Incl. w/coal handling</u>
Deaerator	<u>12,000</u>
Heaters	<u>Incl. w/boiler</u>
Boiler feed pumps	<u>18,000</u>
Condensate system	<u>10,000</u>
Water treating system	<u>16,000</u>
Chemical feed	<u>2,000</u>
Coal handling system	<u>657,700</u>
Ash disposal system	<u>271,400</u>
Thawing equipment	<u>Incl. w/coal handling</u>
Fuel-oil system	<u>N.A.</u>

N.A. - Not applicable.

TABLE A-63.(continued)

INSTALLATION COSTS, DIRECT (cont.)	
Foundations and supports	344,500
Duct work (not incl. w/boiler)	N.A.
Piping	130,500
Insulation	114,800
Painting	16,700
Electrical	340,000
Buildings	678,600
Total installation cost	\$ 4,987,700
TOTAL DIRECT COSTS (equipment + installation)	\$ 12,380,700
INSTALLATION COSTS, INDIRECT	
Engineering (10% of direct costs)	\$ 1,238,100
Construction and field expense (10% of direct costs)	1,238,100
Construction fees (10% of direct costs)	1,238,100
Startup (2% of direct costs)	247,600
Performance tests (minimum \$2000)	15,000
TOTAL INDIRECT COSTS	\$ 3,976,900
Contingencies (20% of direct and indirect costs)	\$ 3,271,500
Total Turnkey Costs (direct+indirect+contingencies)	19,629,100
Land	4,000
Working capital (25% of total direct operating costs)	1,074,200
GRAND TOTAL (turnkey+land+working capital)	\$ 20,707,300

^a Quote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-64. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
MEDIUM-SULFUR COAL WITH A THERMAL INPUT OF 117.2 MW
(400 x 10⁶ Btu/hr; 750 psig/750°F design)

DIRECT COST	
Direct labor	\$ 737,100
Supervision	205,400
Maintenance labor	384,500
Maintenance materials	a
Replacement parts	365,400
Electricity	501,100
Steam	N.A.
Cooling water	N.A.
Process water	6,100
Fuel	1,997,000
Bottom ash disposal	84,000
Chemicals	16,000
Total direct cost	\$ 4,296,600
OVERHEAD	
Payroll (30% of direct labor)	\$ 221,100
Plant (26% of labor, parts & maint.)	440,000
Total overhead costs	\$ 661,100
BYRRODUCT CREDITS	N.A.
CAPITAL CHARGES	
G & A, taxes & insurance (4% of total turnkey costs)	\$ 785,200
Capital recovery factor (10.14% of total turnkey costs)	1,990,400
Interest on working capital (10% of working capital)	107,400
Total capital charges	\$ 2,883,000
TOTAL ANNUALIZED COSTS	\$ 7,840,700

a Included with replacement parts.
N.A. - Not applicable.

TABLE A-65. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
HIGH-SULFUR COAL WITH A THERMAL INPUT OF 205.1 MW
(700 x 10⁶ Btu/hr; 900 psig/750°F design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 6,487,000
Stack	1,250,000
Instrumentation	610,800
Pulverizers	1,625,000
Feeders	334,000
Crushers	incl. w/coal handling
Deaerators	85,000
Heaters	incl. w/boiler
Boiler feed pumps	195,000
Condensate systems	35,000
Water treating system	90,000
Chemical feed	4,000
Compressed air system	60,000
Coal handling system	1,747,000
Ash disposal system	819,000
Thawing equipment	incl. w/coal handling
Fuel-oil system	N.A.
Total Equipment Cost	\$13,341,800

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 3,604,000
Stack	incl. w/equipment
Instrumentation	160,000
Pulverizers	incl. w/boiler
Feeders	incl. w/boiler
Crushers	incl. w/coal handling
Deaerators	19,000
Heaters	incl. w/boiler
Boiler feed pumps	25,000
Condensate system	16,000
Water treating system	28,000
Chemical feed	2,000
Coal handling system	1,092,000
Ash disposal system	546,000
Thawing equipment	incl. w/coal handling
Fuel-oil system	N.A.

N.A. - Not applicable.

TABLE A-65. (continued)

INSTALLATION COSTS, DIRECT (cont.)

Foundations and supports	<u>710,000</u>
Ductwork (not incl. w/boiler)	<u>N.A.</u>
Piping	<u>262,000</u>
Insulation	<u>208,000</u>
Painting	<u>32,000</u>
Electrical	<u>650,000</u>
Buildings	<u>1,365,000</u>
Total installation cost	<u>\$ 8,719,000</u>

TOTAL DIRECT COSTS (equipment + installation)	<u>\$22,060,800</u>
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INSTALLATION COSTS, INDIRECT

Engineering (10% of direct costs)	<u>\$ 2,206,100</u>
Construction and field expense (10% of direct costs)	<u>2,206,100</u>
Construction fees (10% of direct costs)	<u>2,206,100</u>
Start-up (2% of direct costs)	<u>441,200</u>
Performance tests (minimum \$2000)	<u>25,000</u>

TOTAL INDIRECT COSTS	<u>\$ 7,084,500</u>
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Contingencies (20% of direct and indirect costs)	<u>\$ 5,829,100</u>
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Total Turnkey Costs (direct+indirect+contingencies)	<u>34,974,400</u>
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Land	<u>2,000</u>
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Working capital (25% of total direct operating costs)	<u>1,513,800</u>
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GRAND TOTAL (turnkey+land+working capital)	<u>\$36,490,200</u>
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^aQuote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-66. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
HIGH-SULFUR COAL WITH A THERMAL INPUT OF 205.1 MW
(700 x 10⁶ Btu/hr; 900 psig/750°F design)

DIRECT COST	
Direct labor	\$ 1,000,300
Supervision	205,400
Maintenance labor	512,600
Maintenance materials	a
Replacement parts	463,300
Electricity	983,000
Steam	N.A.
Cooling water	N.A.
Process water	10,600
Fuel	2,722,600
Bottom ash disposal	132,500
Chemicals	25,000
Total direct cost	\$ 6,055,300
OVERHEAD	
Payroll (30% of direct labor	\$ 300,100
Plant (26% of labor, parts & maint.)	567,200
Total overhead costs	\$ 867,300
BY-PRODUCT CREDITS	N.A.
CAPITAL CHARGES	
G & A, taxes & insurance (4% of total turnkey costs)	\$ 1,399,000
Capital recovery factor (10.14 % of total turnkey costs)	3,546,400
Interest on working capital (10% of working capital)	151,400
Total capital charges	\$ 5,096,800
TOTAL ANNUALIZED COSTS	\$12,019,400
a Included with replacement parts.	
N.A. - Not applicable.	

TABLE A-67. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
LOW-SULFUR COAL WITH A THERMAL INPUT OF 205.1 MW
(700 x 10⁶ Btu/hr; 900 psig/750°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	<u>\$ 5,524,000</u>
Stack	<u>1,250,000</u>
Instrumentation	<u>610,800</u>
Pulverizers	<u>1,384,000</u>
Feeders	<u>284,000</u>
Crushers	<u>incl. w/coal handling</u>
Deaerators	<u>85,000</u>
Heaters	<u>incl. w/boiler</u>
Boiler feed pumps	<u>195,000</u>
Condensate systems	<u>35,000</u>
Water treating system	<u>90,000</u>
Chemical feed	<u>4,000</u>
Compressed air system	<u>51,000</u>
Coal handling system	<u>1,488,000</u>
Ash disposal system	<u>698,000</u>
Thawing equipment	<u>incl. w/coal handling</u>
Fuel-oil system	<u>N.A.</u>
Total Equipment Cost	<u>\$11,698,800</u>

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	<u>\$ 3,069,000</u>
Stack	<u>incl. w/equipment</u>
Instrumentation	<u>160,000</u>
Pulverizers	<u>incl. w/boiler</u>
Feeders	<u>incl. w/boiler</u>
Crushers	<u>incl. w/coal handling</u>
Deaerators	<u>19,000</u>
Heaters	<u>incl. w/boiler</u>
Boiler feed pumps	<u>25,000</u>
Condensate system	<u>16,000</u>
Water treating system	<u>28,000</u>
Chemical feed	<u>2,000</u>
Coal handling system	<u>930,000</u>
Ash disposal system	<u>465,000</u>
Thawing equipment	<u>incl. w/coal handling</u>
Fuel-oil system	<u>N.A.</u>

N.A. - Not applicable.

TABLE A-67. (continued)

<u>INSTALLATION COSTS, DIRECT (cont.)</u>	
Foundations and supports	605,000
Ductwork (not incl. w/boiler)	N.A.
Piping	223,000
Insulation	177,000
Painting	27,000
Electrical	650,000
Buildings	1,163,000
Total installation cost	<u>\$ 7,559,000</u>
TOTAL DIRECT COSTS (equipment + installation)	<u>\$19,257,800</u>
<u>INSTALLATION COSTS, INDIRECT</u>	
Engineering (10% of direct costs)	<u>\$ 1,925,800</u>
Construction and field expense (10% of direct costs)	<u>1,925,800</u>
Construction fees (10% of direct costs)	<u>1,925,800</u>
Start-up (2% of direct costs)	<u>385,200</u>
Performance tests (minimum \$2000)	<u>25,000</u>
TOTAL INDIRECT COSTS	<u>\$ 6,187,600</u>
Contingencies (20% of direct and indirect costs)	<u>\$ 5,089,100</u>
Total Turnkey Costs (direct+indirect+contingencies)	<u>30,534,500</u>
Land	<u>2,000</u>
Working capital (25% of total direct operating costs)	<u>1,832,700</u>
GRAND TOTAL (turnkey+land+working capital)	<u><u>\$32,369,200</u></u>

^aQuote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-68. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
LOW-SULFUR COAL WITH A THERMAL INPUT OF 205.1 MW
(700 x 10⁶ Btu/hr; 900 psig/750°F design)

DIRECT COST

Direct labor	<u>\$ 1,000,300</u>
Supervision	<u>205,400</u>
Maintenance labor	<u>512,600</u>
Maintenance materials	<u>a</u>
Replacement parts	<u>395,300</u>
Electricity	<u>840,100</u>
Steam	<u>N.A.</u>
Cooling water	<u>N.A.</u>
Process water	<u>10,600</u>
Fuel	<u>4,267,900</u>
Bottom ash disposal	<u>73,600</u>
Chemicals	<u>25,000</u>
Total direct cost	<u>\$ 7,330,800</u>

OVERHEAD

Payroll (30% of direct labor)	<u>\$ 300,100</u>
Plant (26% of labor, parts & maint.)	<u>549,500</u>
Total overhead costs	<u>\$ 849,600</u>

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	<u>\$ 1,221,400</u>
Capital recovery factor (10.14 % of total turnkey costs)	<u>3,096,200</u>
Interest on working capital (10% of working capital)	<u>183,300</u>
Total capital charges	<u>\$ 4,500,900</u>

TOTAL ANNUALIZED COSTS \$12,681,300

a Included with replacement parts.

N.A. - Not applicable.

TABLE A-69. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING SUBBITUMINOUS
COAL WITH A THERMAL INPUT OF 205.1 MW
(700 x 10⁶ Btu/hr; 900 psig/750°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 7,960,000
Stack	1,250,000
Instrumentation	610,800
Pulverizers	1,994,000
Feeders	409,000
Crushers	incl. w/coal handling
Deaerators	85,000
Heaters	incl. w/boiler
Boiler feed pumps	195,000
Condensate systems	35,000
Water treating system	90,000
Chemical feed	4,000
Compressed air system	74,000
Coal handling system	2,144,000
Ash disposal system	1,005,000
Thawing equipment	incl. w/coal handling
Fuel-oil system	N.A.
Total Equipment Cost	\$15,855,800

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 4,422,000
Stack	incl. w/equipment
Instrumentation	160,000
Pulverizers	incl. w/boiler
Feeders	incl. w/boiler
Crushers	incl. w/coal handling
Deaerators	19,000
Heaters	incl. w/boiler
Boiler feed pumps	25,000
Condensate system	16,000
Water treating system	28,000
Chemical feed	2,000
Coal handling system	1,340,000
Ash disposal system	670,000
Thawing equipment	incl. w/coal handling
Fuel-oil system	N.A.

N.A. - Not applicable.

TABLE A-69. (continued)

INSTALLATION COSTS, DIRECT (cont.)	
Foundations and supports	871,000
Ductwork (not incl. w/boiler)	N.A.
Piping	322,000
Insulation	255,000
Painting	39,000
Electrical	650,000
Buildings	1,675,000
Total installation cost	\$10,494,000
TOTAL DIRECT COSTS (equipment + installation)	\$26,349,800
INSTALLATION COSTS, INDIRECT	
Engineering (10% of direct costs)	\$ 2,635,000
Construction and field expense (10% of direct costs)	2,635,000
Construction fees (10% of direct costs)	2,635,000
Start-up (2% of direct costs)	527,000
Performance tests (minimum \$2000)	25,000
TOTAL INDIRECT COSTS	\$ 8,457,000
Contingencies (20% of direct and indirect costs)	\$ 6,961,400
Total Turnkey Costs (direct+indirect+contingencies)	41,768,200
Land	2,000
Working capital (25% of total direct operating costs)	1,290,100
GRAND TOTAL (turnkey+land+working capital)	\$43,060,300

^aQuote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-70. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING SUBBITUMINOUS
COAL WITH A THERMAL INPUT OF 205.1 MW
(700 x 10⁶ Btu/hr; 900 psig/750°F design)

DIRECT COST

Direct labor	\$ 1,000,300
Supervision	205,400
Maintenance labor	512,600
Maintenance materials	a
Replacement parts	569,500
Electricity	1,209,600
Steam	N.A.
Cooling water	N.A.
Process water	10,600
Fuel	1,545,300
Bottom ash disposal	82,000
Chemicals	25,000
Total direct cost	\$ 5,160,300

OVERHEAD

Payroll (30% of direct labor	\$ 300,100
Plant (26% of labor, parts & maint.)	594,800
Total overhead costs	\$ 894,900

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	\$ 1,670,700
Capital recovery factor (10,14 % of total turnkey costs)	4,235,300
Interest on working capital (10% of working capital)	129,000
Total capital charges	\$ 6,035,000

TOTAL ANNUALIZED COSTS \$12,090,200

a Included with replacement parts.
N.A. - Not applicable.

TABLE A-71. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
MEDIUM-SULFUR COAL WITH A THERMAL INPUT OF 205.1 MW
(700 x 10⁶ Btu/hr; 900 psig/750°F design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 5,762,000
Stack	1,250,000
Instrumentation	610,800
Pulverizers	1,443,000
Feeders	296,000
Crushers	incl. w/coal handling
Deaerators	85,000
Heaters	incl. w/boiler
Boiler feed pumps	195,000
Condensate systems	35,000
Water treating system	90,000
Chemical feed	4,000
Compressed air system	53,000
Coal handling system	1,552,000
Ash disposal system	728,000
Thawing equipment	incl. w/coal handling
Fuel-oil system	N.A.
Total Equipment Cost	\$12,103,800

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 3,201,000
Stack	incl. w/equipment
Instrumentation	160,000
Pulverizers	incl. w/boiler
Feeders	incl. w/boiler
Crushers	incl. w/coal handling
Deaerators	19,000
Heaters	incl. w/boiler
Boiler feed pumps	25,000
Condensate system	16,000
Water treating system	28,000
Chemical feed	2,000
Coal handling system	970,000
Ash disposal system	485,000
Thawing equipment	incl. w/coal handling
Fuel-oil system	N.A.

N.A. - Not applicable.

TABLE A-71. (continued)

<u>INSTALLATION COSTS, DIRECT (cont.)</u>	
Foundations and supports	631,000
Ductwork (not incl. w/boiler)	N.A.
Piping	233,000
Insulation	184,000
Painting	28,000
Electrical	650,000
Buildings	1,213,000
Total installation cost	\$ 7,845,000
TOTAL DIRECT COSTS (equipment + installation)	<u>\$19,948,800</u>
<u>INSTALLATION COSTS, INDIRECT</u>	
Engineering (10% of direct costs)	\$ 1,994,900
Construction and field expense (10% of direct costs)	1,994,900
Construction fees (10% of direct costs)	1,994,900
Start-up (2% of direct costs)	399,000
Performance tests (minimum \$2000)	25,000
TOTAL INDIRECT COSTS	<u>\$ 6,408,700</u>
Contingencies (20% of direct and indirect costs)	<u>\$ 5,271,500</u>
Total Turnkey Costs (direct+indirect+contingencies)	<u>31,629,000</u>
Land	<u>2,000</u>
Working capital (25% of total direct operating costs)	<u>1,671,400</u>
GRAND TOTAL (turnkey+land+working capital)	<u>\$33,302,400</u>

^aQuote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-72. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
MEDIUM-SULFUR COAL WITH A THERMAL INPUT OF 205.1 MW
(700 x 10⁶ Btu/hr; 900 psig/750°F design)

DIRECT COST	
Direct labor	\$ 1,000,300
Supervision	205,400
Maintenance labor	512,600
Maintenance materials	a
Replacement parts	412,300
Electricity	876,800
Steam	N.A.
Cooling water	N.A.
Process water	10,600
Fuel	3,495,200
Bottom ash disposal	147,200
Chemicals	25,000
Total direct cost	\$ 6,685,400
OVERHEAD	
Payroll (30% of direct labor)	\$ 300,100
Plant (26% of labor, parts & maint.)	554,000
Total overhead costs	\$ 854,100
BY-PRODUCT CREDITS	
	N.A.
CAPITAL CHARGES	
G & A, taxes & insurance (4% of total turnkey costs)	\$ 1,265,200
Capital recovery factor (10.14% of total turnkey costs)	3,207,200
Interest on working capital (10% of working capital)	167,100
Total capital charges	\$ 4,639,500
TOTAL ANNUALIZED COSTS	\$12,179,000

a Included with replacement parts.
N.A. - Not applicable.

APPENDIX B

DETAILED CAPITAL AND ANNUALIZED COST TABLES
FOR PACKAGE, FIRE-TUBE BOILERS FIRED BY
RESIDUAL OIL, DISTILLATE OIL, AND
NATURAL GAS

TABLE B-1. ESTIMATED CAPITAL COSTS OF A PACKAGE, FIRE-TUBE
BOILER FIRING RESIDUAL OIL WITH A THERMAL INPUT OF 1.5 MW
(5 x 10⁶ Btu/h; 125 hp; 150 psig/sat. temp. design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 19,100
Stack	2,000
Instrumentation	Incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	Incl. w/condensate
Heaters	N.A.
Boiler feed pumps	3,500
Condensate systems	4,000
Water treating system	1,200
Chemical feed	Incl. w/boiler
Compressed air system	N.A.
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	13,000
Total Equipment Cost	\$ 42,800

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 3,000
Stack	1,000
Instrumentation	Incl. w/ boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	N.A.
Heaters	N.A.
Boiler feed pumps	800
Condensate system	800
Water treating system	1,000
Chemical feed	200
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	3,000

N.A. - Not applicable.

TABLE B-1. (continued)

INSTALLATION COSTS, DIRECT (cont.)	
Foundations and supports	2,500
Ductwork (not incl. w/boiler)	N.A.
Piping	12,000
Insulation	8,000
Painting	2,500
Electrical	10,000
Buildings	35,000
Total installation cost	\$ 79,800
TOTAL DIRECT COSTS (equipment + installation)	\$ 122,600
INSTALLATION COSTS, INDIRECT	
Engineering (10% of direct costs)	\$ 12,300
Construction and field expense (10% of direct costs)	12,300
Construction fees (10% of direct costs)	12,300
Start-up (2% of direct costs)	2,500
Performance tests (minimum \$2000)	2,000
TOTAL INDIRECT COSTS	\$ 41,400
Contingencies (20% of direct and indirect costs)	\$ 32,800
Total Turnkey Costs (direct+indirect+contingencies)	196,800
Land	2,000
Working capital (25% of total direct operating costs)	44,900
GRAND TOTAL (turnkey+land+working capital)	\$ 243,700

^a Quote from Cleaver-Brooks, May 11, 1978.

N.A. - Not applicable.

TABLE B-2. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, FIRE-TUBE
BOILER FIRING RESIDUAL OIL WITH A THERMAL INPUT OF 1.5 MW
(5 x 10⁶ Btu/h; 125 hp; 150 psig/sat. temp. design)

DIRECT COST

Direct labor	\$ 105,300
Supervision	0
Maintenance labor	16,000
Maintenance materials	a
Replacement parts	8,000
Electricity	6,000
Steam	N.A.
Cooling water	N.A.
Process water	100
Fuel	43,600
Bottom ash disposal	N.A.
Chemicals	700
Total direct cost	\$ 179,700

OVERHEAD

Payroll (30% of direct labor)	\$ 31,600
Plant (26% of labor, parts & maint.)	33,600
Total overhead costs	\$ 65,200

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	\$ 7,900
Capital recovery factor (11.75 % of total turnkey costs)	23,100
Interest on working capital (10% of working capital)	4,500
Total capital charges	\$ 35,500

TOTAL ANNUALIZED COSTS	\$ 280,400
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a Included with replacement parts.
N.A. - Not applicable.

TABLE B-3. ESTIMATED CAPITAL COSTS OF A PACKAGE, FIRE-TUBE
BOILER FIRING RESIDUAL OIL WITH A THERMAL INPUT OF 4.4 MW
(15 x 106 Btu/h; 300 hp; 150 psig/sat. temp. design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST a

Boiler (with fans & ducts)	\$ 36,100
Stack	2,700
Instrumentation	Incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	4,000
Heaters	N.A.
Boiler feed pumps	6,100
Condensate systems	5,000
Water treating system	1,400
Chemical feed	Incl. w/boiler
Compressed air system	N.A.
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	22,000
Total Equipment Cost	\$ 77,300

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 5,000
Stack	1,500
Instrumentation	Incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	1,500
Heaters	N.A.
Boiler feed pumps	1,200
Condensate system	1,000
Water treating system	1,500
Chemical feed	400
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	4,000

N.A. - Not applicable.

TABLE B-3. (continued)

INSTALLATION COSTS, DIRECT (cont.)	
Foundations and supports	3,500
Ductwork (not incl. w/boiler)	N.A.
Piping	20,000
Insulation	10,000
Painting	3,000
Electrical	15,000
Buildings	50,000
Total installation cost	\$ 117,600
TOTAL DIRECT COSTS (equipment + installation)	\$ 194,900
INSTALLATION COSTS, INDIRECT	
Engineering (10% of direct costs)	\$ 19,500
Construction and field expense (10% of direct costs)	19,500
Construction fees (10% of direct costs)	19,500
Start-up (2% of direct costs)	3,900
Performance tests (minimum \$2000)	2,000
TOTAL INDIRECT COSTS	\$ 64,400
Contingencies (20% of direct and indirect costs)	\$ 51,900
Total Turnkey Costs (direct+indirect+contingencies)	311,200
Land	2,000
Working capital (25% of total direct operating costs)	91,000
GRAND TOTAL (turnkey+land+working capital)	\$ 404,200

^a Quote from Cleaver-Brooks, May 11, 1978.

N.A. - Not applicable.

TABLE B-4. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, FIRE-TUBE
BOILER FIRING RESIDUAL OIL WITH A THERMAL INPUT OF 4.4 MW
(15 x 10⁶ Btu/h; 300 hp; 150 psig/sat. temp design)

DIRECT COST

Direct labor	\$ 105,300
Supervision	68,500
Maintenance labor	32,000
Maintenance materials	a
Replacement parts	15,000
Electricity	11,600
Steam	N.A.
Cooling water	N.A.
Process water	200
Fuel	130,700
Bottom ash disposal	N.A.
Chemicals	800
Total direct cost	\$ 364,100

OVERHEAD

Payroll (30% of direct labor)	\$ 31,600
Plant (26% of labor, parts & maint.)	57,400
Total overhead costs	\$ 89,000

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	\$ 12,400
Capital recovery factor (11.75 % of total turnkey costs)	36,600
Interest on working capital (10% of working capital)	9,100
Total capital charges	\$ 58,100

TOTAL ANNUALIZED COSTS \$511,200

a Included with replacement parts.

N.A. - Not applicable.

TABLE B-5. ESTIMATED CAPITAL COSTS OF A PACKAGE, FIRE-TUBE
BOILER FIRING RESIDUAL OIL WITH A THERMAL INPUT OF 8.5 MW
(29 x 10⁶ Btu/h; 700 hp; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 51,000
Stack	4,000
Instrumentation	Incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	5,000
Heaters	N.A.
Boiler feed pumps	13,000
Condensate systems	6,000
Water treating system	2,000
Chemical feed	1,400
Compressed air system	N.A.
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	32,000
Total Equipment Cost	\$ 114,400

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 9,000
Stack	2,000
Instrumentation	Incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	2,500
Heaters	N.A.
Boiler feed pumps	3,000
Condensate system	1,000
Water treating system	2,000
Chemical feed	1,500
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	8,000

N.A. - Not applicable.

TABLE B-5. (continued)

INSTALLATION COSTS, DIRECT (cont.)	
Foundations and supports	15,000
Ductwork (not incl. w/boiler)	N.A.
Piping	25,000
Insulation	20,000
Painting	4,000
Electrical	20,000
Buildings	70,000
Total installation cost	\$ 183,000
TOTAL DIRECT COSTS (equipment + installation)	\$ 297,400
INSTALLATION COSTS, INDIRECT	
Engineering (10% of direct costs)	\$ 29,700
Construction and field expense (10% of direct costs)	29,700
Construction fees (10% of direct costs)	29,700
Start-up (2% of direct costs)	5,900
Performance tests (minimum \$2000)	2,000
TOTAL INDIRECT COSTS	\$ 97,000
Contingencies (20% of direct and indirect costs)	\$ 78,900
Total Turnkey Costs (direct+indirect+contingencies)	473,300
Land	2,000
Working capital (25% of total direct operating costs)	127,200
GRAND TOTAL (turnkey+land+working capital)	\$ 602,500

^a Quote from Cleaver-Brooks, May 11, 1978.

N.A. - Not applicable.

TABLE B-6. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, FIRE-TUBE
BOILER FIRING RESIDUAL OIL WITH A THERMAL INPUT OF 8.5 MW
(29 x 10⁶ Btu/h; 700 hp; 150 psig/sat. temp. design)

DIRECT COST	
Direct labor	\$ 105,300
Supervision	68,500
Maintenance labor	32,000
Maintenance materials	a
Replacement parts	25,000
Electricity	24,000
Steam	N.A.
Cooling water	N.A.
Process water	400
Fuel	252,600
Bottom ash disposal	N.A.
Chemicals	1,000
Total direct cost	\$ 508,800
OVERHEAD	
Payroll (30% of direct labor)	\$ 31,600
Plant (26% of labor, parts & maint.)	60,000
Total overhead costs	\$ 91,600
BY-PRODUCT CREDITS	
	N.A.
CAPITAL CHARGES	
G & A, taxes & insurance (4% of total turnkey costs)	\$ 18,900
Capital recovery factor (11.75 % of total turnkey costs)	55,600
Interest on working capital (10% of working capital)	12,700
Total capital charges	\$ 87,200
TOTAL ANNUALIZED COSTS	\$ 687,600
a Included with replacement parts. N.A. - Not applicable.	

TABLE B-7. ESTIMATED CAPITAL COSTS OF A PACKAGE, FIRE-TUBE
BOILER FIRING DISTILLATE OIL WITH A
THERMAL INPUT OF 1.5 MW
(5 x 10⁶ Btu/h; 125 hp; 150 psig/sat. temp. design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST ^a

Boiler (with fans & ducts)	\$ 19,100
Stack	2,000
Instrumentation	Incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	Incl. w/condensate
Heaters	N.A.
Boiler feed pumps	3,500
Condensate systems	4,000
Water treating system	1,200
Chemical feed	Incl. w/boiler
Compressed air system	N.A.
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	10,000
Total Equipment Cost	\$ 39,800

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 3,000
Stack	1,000
Instrumentation	Incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	N.A.
Heaters	N.A.
Boiler feed pumps	800
Condensate system	800
Water treating system	1,000
Chemical feed	200
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	2,500

N.A. - Not applicable.

TABLE B-7. (continued)

INSTALLATION COSTS, DIRECT (cont.)	
Foundations and supports	2,500
Ductwork (not incl. w/boiler)	N.A.
Piping	12,000
Insulation	8,000
Painting	2,500
Electrical	10,000
Buildings	35,000
Total installation cost	\$ 79,300
TOTAL DIRECT COSTS (equipment + installation)	\$ 119,100
INSTALLATION COSTS, INDIRECT	
Engineering (10% of direct costs)	\$ 11,900
Construction and field expense (10% of direct costs)	11,900
Construction fees (10% of direct costs)	11,900
Start-up (2% of direct costs)	2,400
Performance tests (minimum \$2000)	2,000
TOTAL INDIRECT COSTS	\$ 40,100
Contingencies (20% of direct and indirect costs)	\$ 31,800
Total Turnkey Costs (direct+indirect+contingencies)	191,000
Land	2,000
Working capital (25% of total direct operating costs)	48,800
GRAND TOTAL (turnkey+land+working capital)	\$ 241,800

^a Quote from Cleaver-Brooks, May 11, 1978.

N.A. - Not applicable.

TABLE B-8. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, FIRE-TUBE BOILER FIRING DISTILLATE OIL WITH A THERMAL INPUT OF 1.5 MW (5 x 10⁶ Btu/h; 125 hp; 150 psig/sat. temp. design)

DIRECT COST	
Direct labor	\$ 105,300
Supervision	0
Maintenance labor	16,000
Maintenance materials	a
Replacement parts	8,000
Electricity	6,000
Steam	N.A.
Cooling water	N.A.
Process water	100
Fuel	59,100
Bottom ash disposal	N.A.
Chemicals	700
Total direct cost	\$ 195,200
OVERHEAD	
Payroll (30% of direct labor)	\$ 31,600
Plant (26% of labor, parts & maint.)	33,600
Total overhead costs	\$ 65,200
BY-PRODUCT CREDITS	N.A.
CAPITAL CHARGES	
G & A, taxes & insurance (4% of total turnkey costs)	\$ 7,600
Capital recovery factor (11.75 % of total turnkey costs)	22,400
Interest on working capital (10% of working capital)	4,900
Total capital charges	\$ 34,900
TOTAL ANNUALIZED COSTS	\$ 295,300
a Included with replacement parts. N.A. - Not applicable.	

TABLE B-9. ESTIMATED CAPITAL COSTS OF A PACKAGE FIRE-TUBE BOILER FIRING DISTILLATE OIL WITH A THERMAL INPUT OF 4.4 MW (15 x 10⁶ Btu/h; 300 hp; 150 psig/sat. temp. design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans and duct)	\$ 36,100
Stack	2,700
Instrumentation	Incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerator	4,000
Heaters	N.A.
Boiler feed pumps	6,100
Condensate systems	5,000
Water treating system	1,400
Chemical feed	Incl. w/boiler
Compressed air system	N.A.
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	16,000
Total Equipment Cost	\$ 71,300

INSTALLATION COSTS, DIRECT

Boiler (including foundations and steel)	\$ 5,000
Stack	1,500
Instrumentation	Incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerator	1,500
Heaters	N.A.
Boiler feed pumps	1,200
Condensate system	1,000
Water treating system	1,500
Chemical feed	400
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	3,000

N.A. - Not applicable.

TABLE B-9. (continued)

INSTALLATION COSTS, DIRECT (cont.)

Foundations and supports	3,500
Duct work (not incl. w/boiler)	N.A.
Piping	20,000
Insulation	10,000
Painting	3,000
Electrical	15,000
Buildings	50,000

Total Installation Costs	\$ 116,600
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TOTAL DIRECT COSTS

(Equipment + Installation)	\$ 187,900
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INSTALLATION COSTS, INDIRECT

Engineering (10% of direct costs)	\$ 18,800
Construction and field expense (10% of direct costs)	18,800
Construction fees (10% of direct costs)	18,800
Startup (2% of direct costs)	3,800
Performance tests (minimum \$2000)	2,000

TOTAL INDIRECT COSTS	\$ 62,200
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Contingencies (20% of direct and indirect costs)	\$ 50,000
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Total turnkey costs (Direct + Indirect + Contingencies)	300,100
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Land	2,000
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Working capital (25% of total direct operating costs)	102,700
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GRAND TOTAL (Turnkey + Land + Working Capital)	\$ 404,800
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^a Quote from Cleaver-Brooks, May 11, 1978.
N.A. - Not applicable.

TABLE B-10. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, FIRE-TUBE
BOILER FIRING DISTILLATE OIL WITH A THERMAL INPUT OF 4.4 MW
(15 x 10⁶ Btu/h; 300 hp; 150 psig/sat. temp. design)

DIRECT COST

Direct labor	\$ 105,300
Supervision	<u>68,500</u>
Maintenance labor	<u>32,000</u>
Maintenance materials	<u>a</u>
Replacement parts	<u>15,000</u>
Electricity	<u>11,600</u>
Steam	<u>N.A.</u>
Cooling water	<u>N.A.</u>
Process water	<u>200</u>
Fuel	<u>177,400</u>
Bottom ash disposal	<u>N.A.</u>
Chemicals	<u>800</u>
Total direct cost	<u>\$ 410,800</u>

OVERHEAD

Payroll (30% of direct labor)	<u>\$ 31,600</u>
Plant (26% of labor, parts & maint.)	<u>57,400</u>
Total overhead costs	<u>\$ 89,000</u>

BYPRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	<u>\$ 12,000</u>
Capital recovery factor (11.75% of total turnkey costs)	<u>35,300</u>
Interest on working capital (10% of working capital)	<u>10,300</u>
Total capital charges	<u>\$ 57,600</u>

TOTAL ANNUALIZED COSTS	<u>\$ 557,400</u>
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^a Included with replacement parts.

N.A. - Not applicable.

TABLE B-11. ESTIMATED CAPITAL COSTS OF A PACKAGE, FIRE-TUBE BOILER FIRING DISTILLATE OIL WITH A THERMAL INPUT OF 8.5 MW (29 x 10⁶ Btu/h; 700 hp; 150 psig/sat. temp. design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 51,000
Stack	4,000
Instrumentation	Incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	5,000
Heaters	N.A.
Boiler feed pumps	13,000
Condensate systems	6,000
Water treating system	2,000
Chemical feed	1,400
Compressed air system	N.A.
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	25,000

Total Equipment Cost \$ 107,400

INSTALLATION COST, DIRECT

Boiler (including foundations and steel)	\$ 9,000
Stack	2,000
Instrumentation	Incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	2,500
Heaters	N.A.
Boiler feed pumps	3,000
Condensate system	1,000
Water treating system	2,000
Chemical feed	1,500
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	6,000

N.A. - Not applicable.

TABLE B-11. (continued)

INSTALLATION COSTS, DIRECT (cont.)

Foundations and supports	<u>15,000</u>
Ductwork (not incl. w/boiler)	<u>N.A.</u>
Piping	<u>25,000</u>
Insulation	<u>20,000</u>
Painting	<u>4,000</u>
Electrical	<u>20,000</u>
Buildings	<u>70,000</u>
Total installation cost	<u>\$181,000</u>

TOTAL DIRECT COSTS (equipment + installation)	<u>\$288,400</u>
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INSTALLATION COSTS, INDIRECT

Engineering (10% of direct costs)	<u>\$ 28,800</u>
Construction and field expense (10% of direct costs)	<u>28,800</u>
Construction fees (10% of direct costs)	<u>28,800</u>
Start-up (2% of direct costs)	<u>5,800</u>
Performance tests (minimum \$2000)	<u>2,000</u>

TOTAL INDIRECT COSTS	<u>\$ 94,200</u>
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Contingencies (20% of direct and indirect costs)	<u>\$ 76,500</u>
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Total Turnkey Costs (direct+indirect+contingencies)	<u>459,100</u>
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Land	<u>2,000</u>
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Working capital (25% of total direct operating costs)	<u>149,800</u>
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GRAND TOTAL (turnkey+land+working capital)	<u>\$610,900</u>
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^a Quote from Cleaver-Brooks, May 11, 1978.

N.A. - Not applicable.

TABLE B-12. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, FIRE-TUBE BOILER FIRING DISTILLATE OIL WITH A THERMAL INPUT OF 8.5 MW (29 x 10⁶ Btu/h; 700 hp; 150 psig/sat. temp. design)

DIRECT COST

Direct labor	\$ 105,300
Supervision	<u>68,500</u>
Maintenance labor	<u>32,000</u>
Maintenance materials	<u>a</u>
Replacement parts	<u>25,000</u>
Electricity	<u>24,000</u>
Steam	<u>N.A.</u>
Cooling water	<u>N.A.</u>
Process water	<u>400</u>
Fuel	<u>343,000</u>
Bottom ash disposal	<u>N.A.</u>
Chemicals	<u>1,000</u>
Total direct cost	<u>\$ 599,200</u>

OVERHEAD

Payroll (30% of direct labor)	<u>\$ 31,600</u>
Plant (26% of labor, parts & maint.)	<u>60,000</u>
Total overhead costs	<u>\$ 91,600</u>

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	<u>\$ 18,400</u>
Capital recovery factor (11.75 % of total turnkey costs)	<u>53,900</u>
Interest on working capital (10% of working capital)	<u>15,000</u>
Total capital charges	<u>\$ 87,300</u>

TOTAL ANNUALIZED COSTS \$ 778,100

a Included with replacement parts.
N.A. - Not applicable.

TABLE B-13. ESTIMATED CAPITAL COSTS OF A PACKAGE, FIRE-TUBE
BOILER FIRING NATURAL GAS WITH A THERMAL INPUT OF 1.5 MW
(5 x 10⁶ Btu/h; 125 hp; 150 psig/sat. temp. design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST ^a

Boiler (with fans & ducts)	\$ 19,100
Stack	2,000
Instrumentation	Incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	Incl. w/condensate
Heaters	N.A.
Boiler feed pumps	3,500
Condensate systems	4,000
Water treating system	1,200
Chemical feed	Incl. w/boiler
Compressed air system	N.A.
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	10,000
Total Equipment Cost	\$ 39,800

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 3,000
Stack	1,000
Instrumentation	Incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	N.A.
Heaters	N.A.
Boiler feed pumps	800
Condensate system	800
Water treating system	1,000
Chemical feed	200
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	2,500

N.A. - Not applicable.

TABLE B-13. (continued)

INSTALLATION COSTS, DIRECT (cont.)

Foundations and supports	<u>2,500</u>
Ductwork (not incl. w/boiler)	<u>N.A.</u>
Piping	<u>12,000</u>
Insulation	<u>8,000</u>
Painting	<u>2,500</u>
Electrical	<u>10,000</u>
Buildings	<u>35,000</u>

Total installation cost	\$ <u>79,300</u>
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TOTAL DIRECT COSTS (equipment + installation)	\$ <u>119,100</u>
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INSTALLATION COSTS, INDIRECT

Engineering (10% of direct costs)	\$ <u>11,900</u>
Construction and field expense (10% of direct costs)	<u>11,900</u>
Construction fees (10% of direct costs)	<u>11,900</u>
Start-up (2% of direct costs)	<u>2,400</u>
Performance tests (minimum \$2000)	<u>2,000</u>

TOTAL INDIRECT COSTS	\$ <u>40,100</u>
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Contingencies (20% of direct and indirect costs)	\$ <u>31,800</u>
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Total Turnkey Costs (direct+indirect+contingencies)	<u>191,000</u>
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Land	<u>2,000</u>
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Working capital (25% of total direct operating costs)	<u>43,600</u>
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GRAND TOTAL (turnkey+land+working capital)	\$ <u>236,600</u>
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^a Quote from Cleaver-Brooks, May 11, 1978.

N.A. - Not applicable.

TABLE B-14. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, FIRE-TUBE
BOILER FIRING NATURAL GAS WITH A THERMAL INPUT OF 1.5 MW
(5 x 10⁶ Btu/h; 125 hp; 150 psig/sat. temp. design)

DIRECT COST

Direct labor	\$ <u>105,300</u>
Supervision	<u>0</u>
Maintenance labor	<u>16,000</u>
Maintenance materials	<u>a</u>
Replacement parts	<u>8,000</u>
Electricity	<u>6,000</u>
Steam	<u>N.A.</u>
Cooling water	<u>N.A.</u>
Process water	<u>100</u>
Fuel	<u>38,400</u>
Bottom ash disposal	<u>N.A.</u>
Chemicals	<u>700</u>
Total direct cost	\$ <u>174,500</u>

OVERHEAD

Payroll (30% of direct labor)	\$ <u>31,600</u>
Plant (26% of labor, parts & maint.)	<u>33,600</u>
Total overhead costs	\$ <u>65,200</u>

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	\$ <u>7,600</u>
Capital recovery factor (11.75% of total turnkey costs)	<u>22,400</u>
Interest on working capital (10% of working capital)	<u>4,400</u>
Total capital charges	\$ <u>34,400</u>

TOTAL ANNUALIZED COSTS \$ 274,100

a Included with replacement parts.

N.A. - Not applicable.

TABLE B-15. ESTIMATED CAPITAL COSTS OF A PACKAGE, FIRE-TUBE
BOILER FIRING NATURAL GAS WITH A THERMAL INPUT OF 4.4 MW
(15 x 10 Btu/h; 300 hp; 150 psig/sat. temp. design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans and ducts)	\$ 36.100
Stack	2.700
Instrumentation	Incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerator	4.000
Heaters	N.A.
Boiler feed pumps	6.100
Condensate systems	5.000
Water treating system	1.400
Chemical feed	Incl. w/boiler
Compressed air system	N.A.
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	16.000
Total Equipment Cost	\$ 71,300

INSTALLATION COSTS, DIRECT

Boiler (including founda- tions and steel)	\$ 5,000
Stack	1,500
Instrumentation	Incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerator	1,500
Heaters	N.A.
Boiler feed pumps	1.200
Condensate system	1.000
Water treating system	1,500
Chemical feed	400
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	3.000

N.A. - Not applicable.

TABLE B-15.(continued)

INSTALLATION COSTS, DIRECT (cont.)	
Foundations and supports	3,500
Duct work (not incl. w/boiler)	N.A.
Piping	20,000
Insulation	10,000
Painting	3,000
Electrical	15,000
Buildings	50,000
Total Installation Costs	\$ 116,600
TOTAL DIRECT COSTS (Equipment + Installation)	\$ 187,900
INSTALLATION COSTS, INDIRECT	
Engineering (10% of direct costs)	\$ 18,800
Construction and field expense (10% of direct costs)	18,800
Construction fees (10% of direct costs)	18,800
Startup (2% of direct costs)	3,800
Performance tests (minimum \$2000)	2,000
TOTAL INDIRECT COSTS	\$ 62,200
Contingencies (20% of direct and indirect costs)	\$ 50,000
Total turnkey costs (Direct + Indirect + Contingencies)	300,100
Land	2,000
Working capital (25% of total direct operating costs)	87,200
GRAND TOTAL (Turnkey + Land + Working Capital)	\$ 389,300 ✓

^a Quote from Cleaver-Brooks, May 11, 1978.

N.A. - Not applicable.

TABLE B-16. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, FIRE-TUBE
BOILER FIRING NATURAL GAS WITH A THERMAL INPUT OF 4.4 MW
(15 x 10⁶ Btu/h; 300 hp; 150 psig/sat. temp. design)

DIRECT COST	
Direct labor	\$ 105,300
Supervision	68,500
Maintenance labor	32,000
Maintenance materials	a
Replacement parts	15,000
Electricity	11,600
Steam	N.A.
Cooling water	N.A.
Process water	200
Fuel	115,300
Bottom ash disposal	N.A.
Chemicals	800
Total direct cost	\$ 348,700
OVERHEAD	
Payroll (30% of direct labor)	\$ 31,600
Plant (26% of labor, parts & maint.)	57,400
Total overhead costs	\$ 89,000
BYPRODUCT CREDITS	N.A.
CAPITAL CHARGES	
G & A, taxes & insurance (4% of total turnkey costs)	\$ 12,000
Capital recovery factor (11.75% of total turnkey costs)	35,300
Interest on working capital (10% of working capital)	8,700
Total capital charges	\$ 56,000
TOTAL ANNUALIZED COSTS	\$ 493,700

^a Included with replacement parts.

N.A. - Not applicable.

TABLE B-17. ESTIMATED CAPITAL COSTS OF A PACKAGE, FIRE-TUBE
BOILER FIRING NATURAL GAS WITH A THERMAL INPUT OF 8.5 MW
(29 x 10⁶ Btu/h; 700 hp; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST ^a

Boiler (with fans & ducts)	\$ 51,000
Stack	4,000
Instrumentation	Incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	5,000
Heaters	N.A.
Boiler feed pumps	13,000
Condensate systems	6,000
Water treating system	2,000
Chemical feed	1,400
Compressed air system	N.A.
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	25,000
Total Equipment Cost	\$ 107,400

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 9,000
Stack	2,000
Instrumentation	Incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	2,500
Heaters	N.A.
Boiler feed pumps	3,000
Condensate system	1,000
Water treating system	2,000
Chemical feed	1,500
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	6,000

N.A. - Not applicable.

TABLE B-17. (continued)

INSTALLATION COSTS, DIRECT (cont.)	
Foundations and supports	15,000
Ductwork (not incl. w/boiler)	N.A.
Piping	25,000
Insulation	20,000
Painting	4,000
Electrical	20,000
Buildings	70,000
Total installation cost	\$ 181,000
TOTAL DIRECT COSTS (equipment + installation)	\$ 288,400
INSTALLATION COSTS, INDIRECT	
Engineering (10% of direct costs)	\$ 28,800
Construction and field expense (10% of direct costs)	28,800
Construction fees (10% of direct costs)	28,800
Start-up (2% of direct costs)	5,800
Performance tests (minimum \$2000)	2,000
TOTAL INDIRECT COSTS	\$ 94,200
Contingencies (20% of direct and indirect costs)	\$ 76,500
Total Turnkey Costs (direct+indirect+contingencies)	459,100
Land	2,000
Working capital (25% of total direct operating costs)	119,800
GRAND TOTAL (turnkey+land+working capital)	\$ 580,900

^a Quote from Cleaver-Brooks, May 11, 1978.

N.A. - Not applicable.

TABLE B-18. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, FIRE-TUBE
BOILER FIRING NATURAL GAS WITH A THERMAL INPUT OF 8.5 MW
(29 x 10⁶ Btu/h; 700 hp; 150 psig/sat. temp. design)

DIRECT COST	
Direct labor	\$ 105,300
Supervision	68,500
Maintenance labor	32,000
Maintenance materials	a
Replacement parts	25,000
Electricity	24,000
Steam	N.A.
Cooling water	N.A.
Process water	400
Fuel	222,900
Bottom ash disposal	N.A.
Chemicals	1,000
Total direct cost	\$ 479,100
OVERHEAD	
Payroll (30% of direct labor)	\$ 31,600
Plant (26% of labor, parts & maint.)	60,000
Total overhead costs	\$ 91,600
BY-PRODUCT CREDITS	N.A.
CAPITAL CHARGES	
G & A, taxes & insurance (4% of total turnkey costs)	\$ 18,400
Capital recovery factor (11.75 % of total turnkey costs)	53,900
Interest on working capital (10% of working capital)	12,000
Total capital charges	\$ 84,300
TOTAL ANNUALIZED COSTS	\$ 655,000

a Included with replacement parts.
N.A. - Not applicable.

APPENDIX C
DETAILED CAPITAL AND ANNUALIZED COST TABLES
FOR DUAL-FUEL BOILERS

TABLE C-1. ESTIMATED CAPITAL COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING RESIDUAL OIL/NATURAL GAS
WITH A THERMAL INPUT OF 8.8 MW
(30 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 150,000
Stack	5,000
Instrumentation	incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	7,000
Heaters	N.A.
Boiler feed pumps	13,500
Condensate systems	3,500
Water treating system	8,000
Chemical feed	1,500
Compressed air system	N.A.
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	33,000
Total Equipment Cost	\$ 221,500

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 10,000
Stack	3,000
Instrumentation	incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	2,500
Heaters	N.A.
Boiler feed pumps	3,000
Condensate system	1,000
Water treating system	2,000
Chemical feed	1,500
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	8,000

N.A. - Not applicable.

TABLE C-1. (continued)

INSTALLATION COSTS, DIRECT (cont.)	
Foundations and supports	15,000
Ductwork (not incl. w/boiler)	N.A.
Piping	29,000
Insulation	20,000
Painting	4,000
Electrical	21,000
Buildings	70,000
Total installation cost	\$ 190,000
TOTAL DIRECT COSTS (equipment + installation)	\$ 411,500
INSTALLATION COSTS, INDIRECT	
Engineering (10% of direct costs)	\$ 41,200
Construction and field expense (10% of direct costs)	41,200
Construction fees (10% of direct costs)	41,200
Start-up (2% of direct costs)	8,200
Performance tests (minimum \$2000)	2,000
TOTAL INDIRECT COSTS	\$ 133,800
Contingencies (20% of direct and indirect costs)	\$ 109,100
Total Turnkey Costs (direct+indirect+contingencies)	654,400
Land	2,000
Working capital (25% of total direct operating costs)	146,500/137,100
GRAND TOTAL (turnkey+land+working capital)	\$ 802,900/793,500

^aQuote from Zurn Industries, Inc., May 25, 1978.
N.A. - Not applicable.

TABLE C-2. ESTIMATED ANNUALIZED COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING RESIDUAL OIL/NATURAL GAS
WITH A THERMAL INPUT OF 8.8 MW
(30 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST	
Direct labor	\$ 105,300
Supervision	68,500
Maintenance labor	32,000
Maintenance materials	a
Replacement parts	30,000
Electricity	29,300
Steam	N.A.
Cooling water	N.A.
Process water	400
Fuel	319,400/281,900
Bottom ash disposal	N.A.
Chemicals	1,000
Total direct cost	\$ 585,900 /548,400
OVERHEAD	
Payroll (30% of direct labor	\$ 31,600
Plant (26% of labor, parts & maint.)	61,300
Total overhead costs	\$ 92,900
BY-PRODUCT CREDITS	
	N.A.
CAPITAL CHARGES	
G & A, taxes & insurance (4% of total turnkey costs)	\$ 26,200
Capital recovery factor (10.61% of total turnkey costs)	69,400
Interest on working capital (10% of working capital)	14,700/13,700
Total capital charges	110,300/109,300
TOTAL ANNUALIZED COSTS	\$ 789,100/750,600

a Included with replacement parts.
N.A. - Not applicable.

TABLE C-3. ESTIMATED CAPITAL COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING RESIDUAL OIL/NATURAL GAS
WITH A THERMAL INPUT OF 17.6 MW
(60 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST ^a

Boiler (with fans & ducts)	\$ 280,000
Stack	9,500
Instrumentation	incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	13,500
Heaters	N.A.
Boiler feed pumps	18,000
Condensate systems	4,500
Water treating system	12,500
Chemical feed	1,500
Compressed air system	N.A.
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	41,000
Total Equipment Cost	\$ 380,500

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 15,500
Stack	4,700
Instrumentation	incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	3,000
Heaters	N.A.
Boiler feed pumps	4,800
Condensate system	1,100
Water treating system	2,100
Chemical feed	1,500
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	15,500

N.A. - Not applicable.

TABLE C-3. (continued)

INSTALLATION COSTS, DIRECT (cont.)	
Foundations and supports	21,000
Ductwork (not incl. w/boiler)	N.A.
Piping	43,000
Insulation	22,500
Painting	4,100
Electrical	26,500
Buildings	76,500
Total installation cost	\$ 241,800
TOTAL DIRECT COSTS (equipment + installation)	\$ 622,300
INSTALLATION COSTS, INDIRECT	
Engineering (10% of direct costs)	\$ 62,200
Construction and field expense (10% of direct costs)	62,200
Construction fees (10% of direct costs)	62,200
Start-up (2% of direct costs)	12,400
Performance tests (minimum \$2000)	3,500
TOTAL INDIRECT COSTS	\$ 202,500
Contingencies (20% of direct and indirect costs)	\$ 165,000
Total Turnkey Costs (direct+indirect+contingencies)	989,800
Land	2,000
Working capital (25% of total direct operating costs)	238,700/219,900
GRAND TOTAL (turnkey+land+working capital)	\$1,230,500/1,211,900

^aQuote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE C-4. ESTIMATED ANNUALIZED COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING RESIDUAL OIL/NATURAL GAS
WITH A THERMAL INPUT OF 17.6 MW
(60 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

Direct labor	\$ 105,300
Supervision	68,500
Maintenance labor	64,100
Maintenance materials	a
Replacement parts	42,000
Electricity	32,900
Steam	N.A.
Cooling water	N.A.
Process water	800
Fuel	638,900/563,700
Bottom ash disposal	N.A.
Chemicals	2,200
Total direct cost	\$ 954,700/879,500

OVERHEAD

Payroll (30% of direct labor	\$ 31,600
Plant (26% of labor, parts & maint.)	72,800
Total overhead costs	\$ 104,400

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	\$ 39,600
Capital recovery factor (10.61% of total turnkey costs)	105,000
Interest on working capital (10% of working capital)	23,900/22,000
Total capital charges	\$ 168,500/166,600

TOTAL ANNUALIZED COSTS \$1,227,600/1,150,500

^a Included with replacement parts.
N.A. - Not applicable.

TABLE C-5. ESTIMATED CAPITAL COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING RESIDUAL OIL/NATURAL GAS
WITH A THERMAL INPUT OF 29.3 MW
(100 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 440,000
Stack	12,000
Instrumentation	incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	18,000
Heaters	N.A.
Boiler feed pumps	35,000
Condensate systems	5,500
Water treating system	16,000
Chemical feed	1,500
Compressed air system	N.A.
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	45,000
Total Equipment Cost	\$ 573,000

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 18,000
Stack	5,500
Instrumentation	incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	3,500
Heaters	N.A.
Boiler feed pumps	6,000
Condensate system	1,500
Water treating system	2,500
Chemical feed	1,500
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	18,000

N.A. - Not applicable.

TABLE C-5. (continued)

INSTALLATION COSTS, DIRECT (cont.)

Foundations and supports	25,000
Ductwork (not incl. w/boiler)	N.A.
Piping	57,000
Insulation	25,000
Painting	4,500
Electrical	33,000
Buildings	88,000
Total installation cost	\$ 289,000

TOTAL DIRECT COSTS

(equipment + installation)

\$ 862,000

INSTALLATION COSTS, INDIRECT

Engineering (10% of direct costs)	\$ 86,200
Construction and field expense (10% of direct costs)	86,200
Construction fees (10% of direct costs)	86,200
Start-up (2% of direct costs)	17,200
Performance tests (minimum \$2000)	3,500

TOTAL INDIRECT COSTS

\$ 279,300

Contingencies

(20% of direct and indirect costs)

\$ 228,300

Total Turnkey Costs

(direct+indirect+contingencies)

1,369,600

Land

2,000Working capital (25% of total direct
operating costs)362,400/331,100

GRAND TOTAL

(turnkey+land+working capital)

\$1,734,000/1,702,700^aQuote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE C-6. ESTIMATED ANNUALIZED COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING RESIDUAL OIL/NATURAL GAS
WITH A THERMAL INPUT OF 29.3 MW
(100 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST	
Direct labor	\$ 157,900
Supervision	68,500
Maintenance labor	64,100
Maintenance materials	a
Replacement parts	50,000
Electricity	39,300
Steam	N.A.
Cooling water	N.A.
Process water	1,400
Fuel	1,064,800/939,500
Bottom ash disposal	N.A.
Chemicals	3,700
Total direct cost	\$ 1,449,700/1,324,400
OVERHEAD	
Payroll (30% of direct labor	\$ 47,400
Plant (26% of labor, parts & maint.)	88,500
Total overhead costs	\$ 135,900
BY-PRODUCT CREDITS	
	N.A.
CAPITAL CHARGES	
G & A, taxes & insurance (4% of total turnkey costs)	\$ 54,800
Capital recovery factor (10.61 % of total turnkey costs)	145,300
Interest on working capital (10% of working capital)	36,200/33,100
Total capital charges	\$ 236,300/233,200
TOTAL ANNUALIZED COSTS	\$ 1,821,900/1,693,500

a Included with replacement parts.
N.A. - Not applicable.

TABLE C-7. ESTIMATED CAPITAL COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING RESIDUAL OIL/NATURAL GAS
WITH A THERMAL INPUT OF 44 MW
(150 x 10⁶ Btu/h; 750 psig/750°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 600,000
Stack	14,500
Instrumentation	<u>incl. w/boiler</u>
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	21,600
Heaters	N.A.
Boiler feed pumps	53,600
Condensate systems	6,700
Water treating system	18,000
Chemical feed	1,500
Compressed air system	N.A.
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	50,000
Total Equipment Cost	<u>\$ 765,900</u>

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 20,000
Stack	6,500
Instrumentation	<u>incl. w/boiler</u>
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	4,000
Heaters	N.A.
Boiler feed pumps	7,500
Condensate system	1,500
Water treating system	3,000
Chemical feed	1,500
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	20,000

N.A. - Not applicable.

TABLE C-7. (continued)

<u>INSTALLATION COSTS, DIRECT (cont.)</u>	
Foundations and supports	30,000
Ductwork (not incl. w/boiler)	N.A.
Piping	74,000
Insulation	30,000
Painting	5,000
Electrical	40,000
Buildings	100,000
Total installation cost	\$ 343,000
TOTAL DIRECT COSTS (equipment + installation)	\$ 1,108,900
<u>INSTALLATION COSTS, INDIRECT</u>	
Engineering (10% of direct costs)	\$ 110,900
Construction and field expense (10% of direct costs)	110,900
Construction fees (10% of direct costs)	110,900
Start-up (2% of direct costs)	22,200
Performance tests (minimum \$2000)	3,500
TOTAL INDIRECT COSTS	\$ 358,400
Contingencies (20% of direct and indirect costs)	\$ 293,500
Total Turnkey Costs (direct+indirect+contingencies)	1,760,800
Land	2,000
Working capital (25% of total direct operating costs)	513,800/466,80
GRAND TOTAL (turnkey+land+working capital)	\$ 2,276,600/2,229

^aQuote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE C-8. ESTIMATED ANNUALIZED COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING RESIDUAL OIL/NATURAL GAS
WITH A THERMAL INPUT OF 44 MW
(150 x 10⁶ Btu/h; 750 psig/750°F design)

DIRECT COST	
Direct labor	\$ 210,600
Supervision	68,500
Maintenance labor	64,100
Maintenance materials	a
Replacement parts	60,000
Electricity	47,100
Steam	N.A.
Cooling water	N.A.
Process water	2,100
Fuel	1,597,200/1,409,300
Bottom ash disposal	N.A.
Chemicals	5,500
Total direct cost	\$2,055,100/1,867,200
OVERHEAD	
Payroll (30% of direct labor	\$ 63,200
Plant (26% of labor, parts & maint.)	104,800
Total overhead costs	\$ 168,000
BY-PRODUCT CREDITS	
	N.A.
CAPITAL CHARGES	
G & A, taxes & insurance (4% of total turnkey costs)	\$ 70,400
Capital recovery factor (10.61 % of total turnkey costs)	186,800
Interest on working capital (10% of working capital)	51,400/46,700
Total capital charges	\$ 308,600/303,900
TOTAL ANNUALIZED COSTS	\$2,531,700/2,339,100

a Included with replacement parts.
N.A. - Not applicable.

TABLE C-9. ESTIMATED CAPITAL COSTS OF A DUAL-FUEL, FIELD-ERECTED,
WATER-TUBE BOILER FIRING RESIDUAL OIL/NATURAL GAS
WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750°F design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 1,704,000
Stack	262,800
Instrumentation	182,400
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	29,000
Heaters	N.A.
Boiler feed pumps	58,000
Condensate systems	16,300
Water treating system	20,000
Chemical feed	500
Compressed air system	12,500
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	150,000
Total Equipment Cost	\$ 2,436,500

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 868,000
Stack	50,000
Instrumentation	28,000
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	5,000
Heaters	N.A.
Boiler feed pumps	8,000
Condensate system	2,000
Water treating system	3,500
Chemical feed	1,500
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	75,000

N.A. - Not applicable.

TABLE C-9. (continued)

INSTALLATION COSTS, DIRECT (cont.)	
Foundations and supports	144,000
Ductwork (not incl. w/boiler)	N.A.
Piping	100,000
Insulation	75,000
Painting	8,000
Electrical	128,000
Buildings	304,000
Total installation cost	\$ 1,800,000
TOTAL DIRECT COSTS (equipment + installation)	\$ 4,236,500
INSTALLATION COSTS, INDIRECT	
Engineering (10% of direct costs)	\$ 423,700
Construction and field expense (10% of direct costs)	423,700
Construction fees (10% of direct costs)	423,700
Start-up (2% of direct costs)	84,700
Performance tests (minimum \$2000)	5,000
TOTAL INDIRECT COSTS	\$ 1,360,800
Contingencies (20% of direct and indirect costs)	\$ 1,119,500
Total Turnkey Costs (direct+indirect+contingencies)	6,716,800
Land	2,000
Working capital (25% of total direct operating costs)	693,200/630,500
GRAND TOTAL (turnkey+land+working capital)	\$ 7,412,000/7,349,300

^aQuote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE C-10. ESTIMATED ANNUALIZED COSTS OF A DUAL-FUEL, FIELD-ERECTED
WATER-TUBE BOILER FIRING RESIDUAL OIL/NATURAL GAS
WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750°F design)

DIRECT COST	
Direct labor	\$ 263,200
Supervision	102,700
Maintenance labor	96,100
Maintenance materials	a
Replacement parts	100,000
Electricity	70,700
Steam	N.A.
Cooling water	N.A.
Process water	2,800
Fuel	2,129,600/1,879,00
Bottom ash disposal	N.A.
Chemicals	7,500
Total direct cost	\$2,772,600/2,522,00
OVERHEAD	
Payroll (30% of direct labor	\$ 79,000
Plant (26% of labor, parts & maint.)	146,100
Total overhead costs	\$ 225,100
BY-PRODUCT CREDITS	
	N.A.
CAPITAL CHARGES	
G & A, taxes & insurance (4% of total turnkey costs)	\$ 268,700
Capital recovery factor (10.14% of total turnkey costs)	681,100
Interest on working capital (10% of working capital)	69,300/63,100
Total capital charges	\$1,019,100/1,012,90
TOTAL ANNUALIZED COSTS	\$4,016,800/3,760,00

a Included with replacement parts.
N.A. - Not applicable.

TABLE C-11. ESTIMATED CAPITAL COSTS OF A DUAL-FUEL, FIELD-ERECTED,
WATER-TUBE BOILER FIRING RESIDUAL OIL/NATURAL GAS
WITH A THERMAL INPUT OF 117.2 MW
(400×10^6 Btu/h; 750 psig/750°F design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 2,736,600
Stack	500,000
Instrumentation	302,800
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	60,000
Heaters	N.A.
Boiler feed pumps	150,000
Condensate systems	25,000
Water treating system	60,000
Chemical feed	4,000
Compressed air system	25,000
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	290,000
Total Equipment Cost	\$ 4,153,400

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 1,736,000
Stack	incl. w/equipment
Instrumentation	88,000
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	12,000
Heaters	N.A.
Boiler feed pumps	18,000
Condensate system	10,000
Water treating system	16,000
Chemical feed	2,000
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	145,000

N.A. - Not applicable.

TABLE C-11. (continued)

INSTALLATION COSTS, DIRECT (cont.)

Foundations and supports	264,000
Ductwork (not incl. w/boiler)	N.A.
Piping	156,000
Insulation	100,000
Painting	13,000
Electrical	272,000
Buildings	520,000

Total installation cost	<u>\$ 3,352,000</u>
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TOTAL DIRECT COSTS

(equipment + installation)	<u>\$ 7,505,400</u>
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INSTALLATION COSTS, INDIRECT

Engineering (10% of direct costs)	<u>\$ 750,500</u>
Construction and field expense (10% of direct costs)	<u>750,500</u>
Construction fees (10% of direct costs)	<u>750,500</u>
Start-up (2% of direct costs)	<u>150,100</u>
Performance tests (minimum \$2000)	<u>13,000</u>

TOTAL INDIRECT COSTS	<u>\$ 2,414,600</u>
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Contingencies

(20% of direct and indirect costs)	<u>\$ 1,984,000</u>
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Total Turnkey Costs

(direct+indirect+contingencies)	<u>11,904,000</u>
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Land

<u>2,000</u>

Working capital (25% of total direct operating costs)	<u>1,319,900/1,194,</u>
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GRAND TOTAL

(turnkey+land+working capital)	<u>\$13,225,900/13,100</u>
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^aQuote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE C-12. ESTIMATED ANNUALIZED COSTS OF A DUAL-FUEL, FIELD-ERECTED,
WATER-TUBE BOILER FIRING RESIDUAL OIL/NATURAL GAS
WITH A THERMAL INPUT OF 117.2 MW
(400 x 10⁶ Btu/h; 750 psig/750°F design)

DIRECT COST

Direct labor	\$ 473,800
Supervision	<u>136,900</u>
Maintenance labor	<u>128,200</u>
Maintenance materials	<u>a</u>
Replacement parts	<u>150,000</u>
Electricity	<u>110,000</u>
Steam	<u>N.A.</u>
Cooling water	<u>N.A.</u>
Process water	<u>5,600</u>
Fuel	<u>4,259,100/3,758,000</u>
Bottom ash disposal	<u>N.A.</u>
Chemicals	<u>16,000</u>
Total direct cost	<u>\$ 5,279,600/4,778,500</u>

OVERHEAD

Payroll (30% of direct labor)	<u>\$ 142,100</u>
Plant (26% of labor, parts & maint.)	<u>231,100</u>
Total overhead costs	<u>\$ 373,200</u>

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	<u>\$ 476,200</u>
Capital recovery factor (10.14% of total turnkey costs)	<u>1,207,100</u>
Interest on working capital (10% of working capital)	<u>132,000/119,500</u>
Total capital charges	<u>\$ 1,815,300/1,802,800</u>

TOTAL ANNUALIZED COSTS \$ 7,468,100/6,954,500

a Included with replacement parts.
N.A. - Not applicable.

TABLE C-13. ESTIMATED CAPITAL COSTS OF A DUAL-FUEL, FIELD-ERECTED,
WATER-TUBE BOILER FIRING RESIDUAL OIL/NATURAL GAS
WITH A THERMAL INPUT OF 205.1 MW
(700 x 10⁶ Btu/h; 900 psig/750°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST

Boiler (with fans & ducts)	\$ 4,419,000
Stack	900,000
Instrumentation	489,000
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	85,000
Heaters	N.A.
Boiler feed pumps	195,000
Condensate systems	35,000
Water treating system	90,000
Chemical feed	4,000
Compressed air system	30,000
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	490,000
Total Equipment Cost	\$ 6,737,000

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 2,455,000
Stack	incl. w/equipment
Instrumentation	128,000
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	19,000
Heaters	N.A.
Boiler feed pumps	25,000
Condensate system	16,000
Water treating system	28,000
Chemical feed	2,000
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	245,000

N.A. - Not applicable.

TABLE C-13. (continued)

INSTALLATION COSTS, DIRECT (cont.)

Foundations and supports	484,000
Ductwork (not incl. w/boiler)	N.A.
Piping	279,000
Insulation	165,000
Painting	22,000
Electrical	520,000
Buildings	930,000

Total installation cost	\$ 5,318,000
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TOTAL DIRECT COSTS (equipment + installation)	\$12,055,000
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INSTALLATION COSTS, INDIRECT

Engineering (10% of direct costs)	\$ 1,205,500
Construction and field expense (10% of direct costs)	205,500
Construction fees (10% of direct costs)	1,205,500
Start-up (2% of direct costs)	241,100
Performance tests (minimum \$2000)	16,000

TOTAL INDIRECT COSTS	\$ 3,873,600
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Contingencies (20% of direct and indirect costs)	\$ 3,185,700
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Total Turnkey Costs (direct+indirect+contingencies)	19,114,300
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Land	2,000
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Working capital (25% of total direct operating costs)	2,215,100/1,995,900
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GRAND TOTAL (turnkey+land+working capital)	\$21,331,400/21,112,200
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^aQuote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE C-14. ESTIMATED ANNUALIZED COSTS OF A DUAL-FUEL, FIELD-ERECTED
WATER-TUBE BOILER FIRING RESIDUAL OIL/NATURAL GAS
WITH A THERMAL INPUT OF 205.1 MW
(700 x 10⁶ Btu/h; 900 psig/750°F design)

DIRECT COST

Direct labor	\$ 605,400
Supervision	<u>136,900</u>
Maintenance labor	<u>224,300</u>
Maintenance materials	<u>a</u>
Replacement parts	<u>225,000</u>
Electricity	<u>180,600</u>
Steam	<u>N.A.</u>
Cooling water	<u>N.A.</u>
Process water	<u>9,700</u>
Fuel	<u>7,453,400/6,576,600</u>
Bottom ash disposal	<u>N.A.</u>
Chemicals	<u>25,000</u>
Total direct cost	<u>\$8,860,300/7,983,500</u>

OVERHEAD

Payroll (30% of direct labor)	\$ <u>181,600</u>
Plant (26% of labor, parts & maint.)	<u>309,800</u>
Total overhead costs	<u>\$ 491,400</u>

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	\$ <u>764,600</u>
Capital recovery factor (10.14 % of total turnkey costs)	<u>1,938,200</u>
Interest on working capital (10% of working capital)	<u>221,500/199,600</u>
Total capital charges	<u>\$2,924,300/2,902,400</u>

TOTAL ANNUALIZED COSTS \$12,276,000/11,377,300

a Included with replacement parts.
N.A. - Not applicable.

TABLE C-15. ESTIMATED CAPITAL COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING DISTILLATE OIL/NATURAL GAS
WITH A THERMAL INPUT OF 8.8 MW
(30 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 150,000
Stack	5,000
Instrumentation	incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	7,000
Heaters	N.A.
Boiler feed pumps	13,500
Condensate systems	3,500
Water treating system	8,000
Chemical feed	1,500
Compressed air system	N.A.
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	26,000
Total Equipment Cost	\$ 214,500

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 10,000
Stack	3,000
Instrumentation	incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	2,500
Heaters	N.A.
Boiler feed pumps	3,000
Condensate system	1,000
Water treating system	2,000
Chemical feed	1,500
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	6,000

N.A. - Not applicable.

TABLE C-15. (continued)

INSTALLATION COSTS, DIRECT (cont.)

Foundations and supports	<u>15,000</u>
Ductwork (not incl. w/boiler)	<u>N.A.</u>
Piping	<u>29,000</u>
Insulation	<u>20,000</u>
Painting	<u>4,000</u>
Electrical	<u>21,000</u>
Buildings	<u>70,000</u>

Total installation cost	<u>\$ 188,000</u>
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TOTAL DIRECT COSTS

(equipment + installation)	<u>\$ 402,500</u>
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INSTALLATION COSTS, INDIRECT

Engineering (10% of direct costs)	<u>\$ 40,300</u>
Construction and field expense (10% of direct costs)	<u>40,300</u>
Construction fees (10% of direct costs)	<u>40,300</u>
Start-up (2% of direct costs)	<u>8,100</u>
Performance tests (minimum \$2000)	<u>2,000</u>

TOTAL INDIRECT COSTS	<u>\$ 131,000</u>
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Contingencies

(20% of direct and indirect costs)	<u>\$ 106,700</u>
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Total Turnkey Costs

(direct+indirect+contingencies)	<u>640,200</u>
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Land	<u>2,000</u>
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Working capital (25% of total direct operating costs)	<u>175,000/137,100</u>
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GRAND TOTAL

(turnkey+land+working capital)	<u>\$ 817,200/779,300</u>
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^aQuote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE C-16. ESTIMATED ANNUALIZED COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING DISTILLATE OIL/NATURAL GAS
WITH A THERMAL INPUT OF 8.8 MW
(30 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

Direct labor	\$ 105,300
Supervision	68,500
Maintenance labor	32,000
Maintenance materials	a
Replacement parts	30,000
Electricity	29,300
Steam	N.A.
Cooling water	N.A.
Process water	400
Fuel	433,600/281,900
Bottom ash disposal	N.A.
Chemicals	1,000
Total direct cost	\$ 700,100/548,400

OVERHEAD

Payroll (30% of direct labor)	\$ 31,600
Plant (26% of labor, parts & maint.)	61,300
Total overhead costs	\$ 92,900

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	\$ 25,600
Capital recovery factor (10.61 % of total turnkey costs)	67,900
Interest on working capital (10% of working capital)	17,500/13,700
Total capital charges	\$ 111,000/107,200

TOTAL ANNUALIZED COSTS \$ 904,000/748,500

a Included with replacement parts.
N.A. - Not applicable.

TABLE C-17. ESTIMATED CAPITAL COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING DISTILLATE OIL/NATURAL GAS
WITH A THERMAL INPUT OF 17.6 MW
(60 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 280,000
Stack	9,500
Instrumentation	incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	13,500
Heaters	N.A.
Boiler feed pumps	18,000
Condensate systems	4,500
Water treating system	12,500
Chemical feed	1,500
Compressed air system	N.A.
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	32,000
Total Equipment Cost	\$ 371,500

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 15,500
Stack	4,700
Instrumentation	incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	3,000
Heaters	N.A.
Boiler feed pumps	4,800
Condensate system	1,100
Water treating system	2,100
Chemical feed	1,500
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	11,500

N.A. - Not applicable.

TABLE C-17. (continued)

INSTALLATION COSTS, DIRECT (cont.)	
Foundations and supports	21,000
Ductwork (not incl. w/boiler)	N.A.
Piping	43,000
Insulation	22,500
Painting	4,100
Electrical	26,500
Buildings	76,500
Total installation cost	\$ 237,800
TOTAL DIRECT COSTS (equipment + installation)	\$ 609,300
INSTALLATION COSTS, INDIRECT	
Engineering (10% of direct costs)	\$ 60,900
Construction and field expense (10% of direct costs)	60,900
Construction fees (10% of direct costs)	60,900
Start-up (2% of direct costs)	12,200
Performance tests (minimum \$2000)	3,500
TOTAL INDIRECT COSTS	\$ 198,400
Contingencies (20% of direct and indirect costs)	\$ 161,500
Total Turnkey Costs (direct+indirect+contingencies)	969,200
Land	2,000
Working capital (25% of total direct operating costs)	295,800/219,900
GRAND TOTAL (turnkey+land+working capital)	\$1,267,000/1,191,100

^aQuote from Zurn Industries, Inc., May 25, 1979.

N.A. - Not applicable.

TABLE C-18. ESTIMATED ANNUALIZED COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING DISTILLATE OIL/NATURAL GAS
WITH A THERMAL INPUT OF 17.6 MW
(60 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

Direct labor	\$ 105,300
Supervision	68,500
Maintenance labor	64,100
Maintenance materials	a
Replacement parts	42,000
Electricity	32,900
Steam	N.A.
Cooling water	N.A.
Process water	800
Fuel	867,200/563,700
Bottom ash disposal	N.A.
Chemicals	2,200
Total direct cost	\$1,183,000/879,500

OVERHEAD

Payroll (30% of direct labor	\$ 31,600
Plant (26% of labor, parts & maint.)	72,800
Total overhead costs	\$ 104,400

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	\$ ' 38,800
Capital recovery factor (10.61 % of total turnkey costs)	102,800
Interest on working capital (10% of working capital)	29,600/22,000
Total capital charges	\$ 171,200/163,600

TOTAL ANNUALIZED COSTS \$1,458,600/1,147,50

a Included with replacement parts.

N.A. - Not applicable.

TABLE C-19. ESTIMATED CAPITAL COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING DISTILLATE OIL/NATURAL GAS
WITH A THERMAL INPUT OF 29.3 MW
(100 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 440,000
Stack	12,000
Instrumentation	incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	18,000
Heaters	N.A.
Boiler feed pumps	35,000
Condensate systems	5,500
Water treating system	16,000
Chemical feed	1,500
Compressed air system	N.A.
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	35,000
Total Equipment Cost	\$ 563,000

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 18,000
Stack	5,500
Instrumentation	incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	3,500
Heaters	N.A.
Boiler feed pumps	6,000
Condensate system	1,500
Water treating system	2,500
Chemical feed	1,500
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	13,500

N.A. - Not applicable.

TABLE C-19. (continued)

INSTALLATION COSTS, DIRECT (cont.)

Foundations and supports	25,000
Ductwork (not incl. w/boiler)	N.A.
Piping	57,000
Insulation	25,000
Painting	4,500
Electrical	33,000
Buildings	88,000

Total installation cost	\$ 284,500
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TOTAL DIRECT COSTS

(equipment + installation)	\$ 847,500
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INSTALLATION COSTS, INDIRECT

Engineering (10% of direct costs)	\$ 84,800
Construction and field expense (10% of direct costs)	84,800
Construction fees (10% of direct costs)	84,800
Start-up (2% of direct costs)	17,000
Performance tests (minimum \$2000)	3,500

TOTAL INDIRECT COSTS	\$ 274,900
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Contingencies

(20% of direct and indirect costs)	\$ 224,500
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Total Turnkey Costs

(direct+indirect+contingencies)	1,346,900
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Land

2,000

Working capital (25% of total direct operating costs)	457,600/331,100
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GRAND TOTAL

(turnkey+land+working capital)	\$1,806,500/1,680,000
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^aQuote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE C-20. ESTIMATED ANNUALIZED COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING DISTILLATE OIL/NATURAL GAS
WITH A THERMAL INPUT OF 29.3 MW
(100 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST	
Direct labor	\$ 157,900
Supervision	68,500
Maintenance labor	64,100
Maintenance materials	a
Replacement parts	50,000
Electricity	39,300
Steam	N.A.
Cooling water	N.A.
Process water	1,400
Fuel	1,445,400/939,500
Bottom ash disposal	N.A.
Chemicals	3,700
Total direct cost	\$ 1,830,300/1,324,400
OVERHEAD	
Payroll (30% of direct labor)	\$ 47,400
Plant (26% of labor, parts & maint.)	88,500
Total overhead costs	\$ 135,900
BY-PRODUCT CREDITS	
	N.A.
CAPITAL CHARGES	
G & A, taxes & insurance (4% of total turnkey costs)	\$ 53,900
Capital recovery factor (10.61 % of total turnkey costs)	142,900
Interest on working capital (10% of working capital)	45,800/33,100
Total capital charges	\$ 242,600/229,900
TOTAL ANNUALIZED COSTS	\$ 2,208,800/1,690,200

a Included with replacement parts.
N.A. - Not applicable.

TABLE C-21. ESTIMATED CAPITAL COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING DISTILLATE OIL/NATURAL GAS
WITH A THERMAL INPUT OF 44 MW
(150 x 10⁶ Btu/h; 750 psig/750°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$ 600,000
Stack	14,500
Instrumentation	Incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	21,600
Heaters	N.A.
Boiler feed pumps	53,600
Condensate systems	6,700
Water treating system	18,000
Chemical feed	1,500
Compressed air system	N.A.
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	39,000
Total Equipment Cost	\$ 754,900

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 20,000
Stack	6,500
Instrumentation	Incl. w/boiler
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	4,000
Heaters	N.A.
Boiler feed pumps	7,500
Condensate system	1,500
Water treating system	3,000
Chemical feed	1,500
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	15,000

N.A. - Not applicable.

TABLE C-21. (continued)

INSTALLATION COSTS, DIRECT (cont.)

Foundations and supports	30,000
Ductwork (not incl. w/boiler)	N.A.
Piping	74,000
Insulation	30,000
Painting	5,000
Electrical	40,000
Buildings	100,000

Total installation cost \$ 338,000

TOTAL DIRECT COSTS
(equipment + installation)

\$1,092,900

INSTALLATION COSTS, INDIRECT

Engineering (10% of direct costs)	\$ 109,300
Construction and field expense (10% of direct costs)	109,300
Construction fees (10% of direct costs)	109,300
Start-up (2% of direct costs)	21,900
Performance tests (minimum \$2000)	3,500

TOTAL INDIRECT COSTS

\$ 353,300

Contingencies
(20% of direct and indirect costs)

\$ 289,200

Total Turnkey Costs
(direct+indirect+contingencies)

1,735,400

Land

2,000

Working capital (25% of total direct
operating costs)

656,500/
466,800

GRAND TOTAL
(turnkey+land+working capital)

\$2,393,900/
2,204,200

^aBased on quote from Zurn Industries, Inc., May 25, 1978.
N.A. - Not applicable.

TABLE C-22. ESTIMATED ANNUALIZED COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING DISTILLATE OIL/NATURAL GAS
WITH A THERMAL INPUT OF 44 MW
(150 x 10⁶ Btu/h, 750 psig/750°F design)

DIRECT COST

Direct labor	\$ 210,600
Supervision	68,500
Maintenance labor	64,100
Maintenance materials	a
Replacement parts	60,000
Electricity	47,100
Steam	N.A.
Cooling water	N.A.
Process water	2,100
Fuel	2,168,100/1,409,300
Bottom ash disposal	N.A.
Chemicals	5,500
Total direct cost	\$2,626,000/1,867,200

OVERHEAD

Payroll (30% of direct labor	\$ 63,200
Plant (26% of labor, parts & maint.)	104,800
Total overhead costs	\$ 168,000

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A, taxes & insurance (4% of total turnkey costs)	\$ 69,400
Capital recovery factor (10.61 % of total turnkey costs)	184,100
Interest on working capital (10% of working capital)	65,700/46,700
Total capital charges	\$ 319,200/300,200

TOTAL ANNUALIZED COSTS

\$3,113,200/2,335,400

a Included with replacement parts.
N.A. - Not applicable.

TABLE C-23. ESTIMATED CAPITAL COSTS OF A DUAL-FUEL, FIELD-
ERECTED, WATER-TUBE BOILER FIRING DISTILLATE OIL/NATURAL
GAS WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750°F design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST ^a

Boiler (with fans & ducts)	\$ 1,704,000
Stack	262,800
Instrumentation	182,400
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	29,000
Heaters	N.A.
Boiler feed pumps	58,000
Condensate systems	16,300
Water treating system	20,000
Chemical feed	1,500
Compressed air system	12,500
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	100,000
Total Equipment Cost	\$ 2,386,500

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 868,000
Stack	50,000
Instrumentation	28,000
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	5,000
Heaters	N.A.
Boiler feed pumps	8,000
Condensate system	2,000
Water treating system	3,500
Chemical feed	1,500
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	50,000

N.A. - Not applicable.

TABLE C-23. (continued)

INSTALLATION COSTS, DIRECT (cont.)	
Foundations and supports	<u>144,000</u>
Ductwork (not incl. w/boiler)	<u>N.A.</u>
Piping	<u>100,000</u>
Insulation	<u>75,000</u>
Painting	<u>8,000</u>
Electrical	<u>128,000</u>
Buildings	<u>304,000</u>
Total installation cost	<u>\$ 1,775,000</u>
TOTAL DIRECT COSTS (equipment + installation)	<u>\$ 4,161,500</u>
INSTALLATION COSTS, INDIRECT	
Engineering (10% of direct costs)	<u>\$ 416,200</u>
Construction and field expense (10% of direct costs)	<u>416,200</u>
Construction fees (10% of direct costs)	<u>416,200</u>
Start-up (2% of direct costs)	<u>83,200</u>
Performance tests (minimum \$2000)	<u>5,000</u>
TOTAL INDIRECT COSTS	<u>\$ 1,336,800</u>
Contingencies (20% of direct and indirect costs)	<u>\$ 1,099,700</u>
Total Turnkey Costs (direct+indirect+contingencies)	<u>6,598,000</u>
Land	<u>2,000</u>
Working capital (25% of total direct operating costs)	<u>883,500/630,500</u>
GRAND TOTAL (turnkey+land+working capital)	<u>\$ 7,483,500/7,230,</u>

^a Based on quote from Babcock & Wilcox, Inc., August 17, 1978.
N.A. - Not applicable.

TABLE C-24. ESTIMATED ANNUALIZED COSTS OF A DUAL-FUEL, FIELD-ERECTED, WATER-TUBE BOILER FIRING DISTILLATE OIL/NATURAL GAS WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750°F design)

DIRECT COST

Direct labor	\$ 263,200
Supervision	102,700
Maintenance labor	96,100
Maintenance materials	^a
Replacement parts	100,000
Electricity	70,700
Steam	N.A.
Cooling water	N.A.
Process water	2,800
Fuel	2,890,800/1,879,000
Bottom ash disposal	N.A.
Chemicals	7,500
Total direct cost	\$ 3,533,800/2,522,000

OVERHEAD

Payroll (30% of direct labor)	\$79,000
Plant (26% of labor, parts & maint.)	146,100
Total overhead costs	\$225,100

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

G & A. taxes & insurance (4% of total turnkey costs)	\$263,900
Capital recovery factor (10.14 % of total turnkey costs)	669,000
Interest on working capital (10% of working capital)	88,400/63,100

Total capital charges \$ 1,021,300/996,000

TOTAL ANNUALIZED COSTS \$ 4,780,200/3,743,100

^a Included with replacement parts.

N.A. - Not applicable.

TABLE C-25. ESTIMATED CAPITAL COSTS OF A DUAL-FUEL, FIELD-ERECTED, WATER-TUBE BOILER FIRING DISTILLATE OIL/NATURAL GAS WITH A THERMAL INPUT OF 117.2 MW
(400 x 10⁶ Btu/h; 750 psig/750°F design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

Boiler (with fans & ducts)	\$2,736,600
Stack	500,000
Instrumentation	302,800
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	60,000
Heaters	N.A.
Boiler feed pumps	150,000
Condensate systems	25,000
Water treating system	60,000
Chemical feed	4,000
Compressed air system	25,000
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	195,000
Total Equipment Cost	\$4,058,400

INSTALLATION COST, DIRECT

Boiler (including foundations and steel)	\$1,736,000
Stack	Incl. w/equip.
Instrumentation	88,000
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	12,000
Heaters	N.A.
Boiler feed pumps	18,000
Condensate system	10,000
Water treating system	16,000
Chemical feed	2,000
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	97,000

N.A. - Not applicable.

TABLE C-25. (continued)

INSTALLATION COSTS, DIRECT (cont.)	
Foundations and supports	264,000
Ductwork (not incl. w/boiler)	N.A.
Piping	156,000
Insulation	100,000
Painting	13,000
Electrical	272,000
Buildings	520,000
Total installation cost	\$3,304,000
TOTAL DIRECT COSTS (equipment + installation)	\$7,362,400
INSTALLATION COSTS, INDIRECT	
Engineering (10% of direct costs)	\$ 736,200
Construction and field expense (10% of direct costs)	736,200
Construction fees (10% of direct costs)	736,200
Start-up (2% of direct costs)	147,200
Performance tests (minimum \$2000)	13,000
TOTAL INDIRECT COSTS	\$2,368,800
Contingencies (20% of direct and indirect costs)	\$1,946,200
Total Turnkey Costs (direct+indirect+contingencies)	11,677,400
Land	2,000
Working capital (25% of total direct operating costs)	1,700,500/1,194,600
GRAND TOTAL (turnkey+land+working capital)	\$13,379,900/12,874,000

^a Based on quote from Babcock & Wilcox, Inc., August 17, 1978.
N.A. - Not applicable.

TABLE C-26. ESTIMATED ANNUALIZED COSTS OF A DUAL-FUEL, FIELD-ERECTED, WATER-TUBE BOILER FIRING DISTILLATE OIL/NATURAL GAS WITH A THERMAL INPUT OF 117.2 MW (400 x 10⁶ Btu/h; 750 psig/750°F design)

DIRECT COST	
Direct labor	\$ 473,800
Supervision	136,900
Maintenance labor	128,200
Maintenance materials	a
Replacement parts	150,000
Electricity	110,000
Steam	N.A.
Cooling water	N.A.
Process water	5,600
Fuel	5,781,600/3,758,800
Bottom ash disposal	N.A.
Chemicals	16,000
Total direct cost	\$ 6,802,100/4,778,500
OVERHEAD	
Payroll (30% of direct labor	\$ 142,100
Plant (26% of labor, parts & maint.)	231,100
Total overhead costs	\$ 373,200
BY-PRODUCT CREDITS	N.A.
CAPITAL CHARGES	
G & A, taxes & insurance (4% of total turnkey costs)	\$ 467,100
Capital recovery factor (10.14 % of total turnkey costs)	1,184,100
Interest on working capital (10% of working capital)	170,100/119,500
Total capital charges	\$ 1,821,300/1,770,700
TOTAL ANNUALIZED COSTS	\$ 8,996,600/6,922,400
a Included with replacement parts.	
N.A. - Not applicable.	

TABLE C-27. ESTIMATED CAPITAL COSTS OF A DUAL-FUEL, FIELD-
ERECTED WATER-TUBE BOILER FIRING DISTILLATE OIL/NATURAL
GAS WITH A THERMAL INPUT OF 205.1 MW
(700 x 10⁶ Btu/h; 900 psig/750°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST ^a

Boiler (with fans & ducts)	\$ 4,419,000
Stack	900,000
Instrumentation	489,000
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	85,000
Heaters	N.A.
Boiler feed pumps	195,000
Condensate systems	35,000
Water treating system	90,000
Chemical feed	4,000
Compressed air system	30,000
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	325,000

Total Equipment Cost \$ 6,572,000

INSTALLATION COST, DIRECT

Boiler (including founda- tions and steel)	\$ 2,455,000
Stack	Incl. w/equip.
Instrumentation	128,000
Pulverizers	N.A.
Feeders	N.A.
Crushers	N.A.
Deaerators	19,000
Heaters	N.A.
Boiler feed pumps	25,000
Condensate system	16,000
Water treating system	28,000
Chemical feed	2,000
Coal handling system	N.A.
Ash disposal system	N.A.
Thawing equipment	N.A.
Fuel-oil system	165,000

N.A. - Not applicable.

TABLE C-27. (continued)

INSTALLATION COSTS, DIRECT (cont.)	
Foundations and supports	484,000
Ductwork (not incl. w/boiler)	N.A.
Piping	279,000
Insulation	165,000
Painting	22,000
Electrical	520,000
Buildings	930,000
Total installation cost	\$ 5,238,000
TOTAL DIRECT COSTS (equipment + installation)	\$11,810,000
INSTALLATION COSTS, INDIRECT	
Engineering (10% of direct costs)	\$ 1,181,000
Construction and field expense (10% of direct costs)	1,181,000
Construction fees (10% of direct costs)	1,181,000
Start-up (2% of direct costs)	236,200
Performance tests (minimum \$2000)	16,000
TOTAL INDIRECT COSTS	\$ 3,795,200
Contingencies (20% of direct and indirect costs)	\$ 3,121,000
Total Turnkey Costs (direct+indirect+contingencies)	18,726,200
Land	2,000
Working capital (25% of total direct operating costs)	2,881,200/1,995,90
GRAND TOTAL (turnkey+land+working capital)	\$21,609,400/20,724,2

^a Based on quote from Babcock & Wilcox, Inc., August 17, 1978.
N.A. - Not applicable.

TABLE C-28. ESTIMATED ANNUALIZED COSTS OF A DUAL-FUEL, FIELD-ERECTED, WATER-TUBE BOILER FIRING DISTILLATE OIL/NATURAL GAS WITH A THERMAL INPUT OF 205.1 MW (700 x 10⁶ Btu/h; 900 psig/750°F design)

DIRECT COST	
Direct labor	\$ 605,400
Supervision	136,900
Maintenance labor	224,300
Maintenance materials	a
Replacement parts	225,000
Electricity	180,600
Steam	N.A.
Cooling water	N.A.
Process water	9,700
Fuel	10,117,800/6,576,600
Bottom ash disposal	N.A.
Chemicals	25,000
Total direct cost	\$11,524,700/7,983,500
OVERHEAD	
Payroll (30% of direct labor	\$ 181,600
Plant (26% of labor, parts & maint.)	309,800
Total overhead costs	\$ 491,400
BY-PRODUCT CREDITS	
	N.A.
CAPITAL CHARGES	
G & A, taxes & insurance (4% of total turnkey costs)	\$ 749,000
Capital recovery factor (10.14 % of total turnkey costs)	1,898,800
Interest on working capital (10% of working capital)	288,100/199,600
Total capital charges	\$ 2,935,900/2,847,400
TOTAL ANNUALIZED COSTS	\$14,952,000/11,322,300

a Included with replacement parts.
N.A. - Not applicable.

United States
Environmental Protection
Agency

Office of Air, Noise, and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park NC 27711

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